A STUDY AND SUMMARY

OF THE INVESTIGATIONAL ACTIVITIES

ON THE McDONALD FOREST WITH RECOMMENDATIONS

by

Harry Ardell Fowells

June, 1933

FOREWORD

In the preparation of this thesis, the writer does not claim to have discovered any great truths or their underlying causes. As the title indicates, the work is a summary of some of the more important investigational activities on the McDonald Forest. This line of endeavor was chosen because it is the belief of the writer that forest research projects which consider time as an element or variable should be kept up-to-date. By so summarizing the data of each period, it is thought that the greatest value will be derived from the problem.

Accordingly, the writer has used much data collected by former students and has augmented it when necessary with data collected by himself. It is not considered necessary to acknowledge the particular individuals who may have collected part of some data assigned to be collected by a class. Rather, the acknowledgement has been made to the class. It has been the policy in the classes in silviculture to require each student to do some piece of original work or to continue a project previously started. This requirement serves a double purpose: the students obtain some experience in the rudiments of research and some facts are derived in the process. Many of the studies covered in this thesis have so originated. In all cases, except where data was collected by the writer, the data was obtained from the original notes filed by the students with Prof. T. J. Starker, the major professor.

In order to expand the investigational activities, the writer has proposed and initiated certain studies but has only done so in cooperation with the under the supervision of Prof. Starker.

It is hoped that ~~x~~this thesis will be of service in so far as it brings up to date the essence of a mass of data.

The writer wishes to express his appreciation to Prof. Starker for his interest, suggestions, and constructive criticisms in the preparation of the manuscript. Acknowledgement is also made to Mr. W. J. Kirkham of the mathematics department who constructively criticised the part on statistical methods and formulas.

The writer has been able to do this work and to benefit himself of other graduate study only through the kindness of Mrs. Mary J. L. McDonald who has established the McDonald fellowship in forestry.

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THE "POST FARM"

OBJECT:

To answer numerous inquiries as to the relative values of different species of wood used for posts and of various preservative treatments on such wood, the technical forestry department of the school of forestry established the so called "Post Farm" in January 1928.

REFERENCES:

Tests have been made by various industrial and public research agencies in regard to the durability and serviceable life of posts. Results from the Missouri Agricultural Experiment Station[1] on posts untreated and treated with creosote are shown in the following table.

Species	Treated	Untreated
Sassafras	*18	14
White Oak	*18	12
White walnut	14	11
Redbud	14	10
Black walnut	*18	9
Black ash	*18	7
Honey Locust	*18	5
Red oak	13	3
Black oak	12	2

The Santa Fe Railway[2] instituted a post test in 1913 to obtain data on the relative life of treated and untreated fence posts. Numerous methods of preservation were tried out. Subsequent examination showed that the untreated pine posts were badly decayed at the

*Some posts still in service.
1. Forest Worker, July, 1932.
2. Wood Preservation News, October, 1924

end of 3 years whereas those treated with the full cell and empty cell process with creosote and zinc chloride were in good condition at the end of 11 years.

Under the supervision of the Forest Service, post farms were established at 7 different colleges and experiment stations in 1908 and 1909. The results[3] of these tests indicate that:

1. Posts should be thoroughly seasoned and all back removed before treatment.

2. For most satisfactory results, butts and tops, both should be treated, the whole treatment being far superior to butt treatment.

3. Brush treatment helped increase the life of posts but did not as much as the open-tank method.

4. Charring posts seems of very little value as a protection against decay.

PERSONNEL:

The study was commenced by the classes in timber technology in January, 1928, under the direction of Prof. T. J. Starker and continued by various classes under Mr. Starker.

METHODS:

The posts were set out at intervals of four feet in rows four feet apart and set to a depth of two and one-half feet. Each post was given a number, indicated by a metal tag nailed to the post.

To test for the failure of the post, a 50 pound pull is exerted on the post two feet from the ground. This is done by placing a rope loop

3. "Service-Tests of Treated and Untreated Fence Posts" J.D.MacLean. Reprint from Seventeenth Annual Proceedings (1921) of the American Wood Preservers Ass. Page 3

around the post two feet from the ground and pulling with a spring scale until the force exerted is indicated as 50 pounds. This method, devised by Prof. Starker, is considered much more accurate than the "reasonable push" advocated by the Forest Products Laboratory. Such tests are made usually in October or November each year.

Failures are recorded on a map of the "Post Farm" by writing in the date of failure at the side of the post.

A description of the treatments of the posts set out is contained in Table I. Table II gives further facts describing the posts.

TABLE I

Serial No.	Species	Treatment
1-15 51-60	Douglas fir Pseudo-tsuga taxifolia	Auger process. One $\frac{3}{4}$" hole was bored into the post at an angle of declination from the horizontal of about 5 degrees. The hole was about 6 inches above the ground line. One ounce of a mixture of 5 ounces of mecuric chloride and 50 ounces of sodium chloride was deposited in the hole which was then plugged with a cork.
16-30 61-70	Douglas fir	No treatment.
31-50 71-75	Douglas fir	Auger process, as above, except that the ounce of mixture was divided among 3 holes.
76-100	Douglas fir	Auger process with the mixture composed of 5 ounces of mercuric chloride, 30 ounces of arsenic, and 50 ounces of sodium chloride. The ounce of mixture was divided between two holes.
101-125	Douglas fir	Treater dust. A patent preservative dust obtained from the Anaconda Copper Co. Ten ounces of dust was used for each post. Application consisted of covering the bottom of the post hole with the dust, making a collar of

		dust around the post about one foot from the surface and making a collar of the dust around the post at the surface.
126-150	Douglas fir	Granulated treater dust. A patent preservative dust obtained from the Anaconda Copper Co. Application was the same as for the treater dust method.
151-175	Douglas fir	Treated by the Southern Pacific Railroad Co. by the pressure treatment using 70% creosote and 30% fuel oil. The average charge per post was 8.1 pounds. These posts were subjected to two treatments to thoroughly impregnate them.
176-197	Douglas fir	"B" treatment. Carbolineum Wood Preservation Co. This is an open tank method.
198-207	Port Orford Cedar tops Chamaecyparis lawsoniani	"B" treatment. Carbolineum Wood Preservation Co.
339-363	Western red cedar (dark) Thuja plicata	No treatment.
364-386	Yew Taxus brevifolia	No treatment
387-411	Cottonwood Populus trichocarpa	Split. No treatment.
412-436	White fir Abies grandis	No treatment.
437-461	Red alder Alnus oregona	No treatment.
462-473	Cascara Rhamnus purshiana	No treatment. Posts too small for good results.
474-498	Big leaf maple Acer macrophyllum	Peeled. No treatment.
499-525	Douglas fir	Steeped for 8 days in 1.19% solution of zinc chloride.

526-550	Western red cedar (light)	No treatment.
551-576	Douglas fir	Open tank method using creosote and crank case oil. An absorption of 0.88 pounds per post was obtained after a treatment for $2\frac{1}{2}$ hours at from 180-220 degrees F.
577-601	Port Orford cedar	No treatment.
602-626	Douglas fir	Charred in an open fire to a depth of about $\frac{1}{4}$".
628-652	Oak Quercus garryana	Split. No treatment.
653-702	Douglas fir	Creosoted by the McCormick Lumber Co. at St. Helens.
703-729	Douglas fir	A.C.M. paste manufactured by the Anaconda Copper Co. Two pounds per post applied to the bottom three feet of the post. The paste was smeared over the surface and bottom.
730-754	Douglas fir	A.C.M. paste. Four pounds applied as above.
800-825	Osage orange Toxylon pomiferum	No treatment.
826-850A	Sitka spruce Picea sitchensis	No treatment.
851-875	Madrone Arbutus menziesii	No treatment.
876-900	Ash Fraxinus oregona	No treatment.
901-925	Incense cedar Libocedrus decurrens	No treatment.
926-947	Western juniper Juniparus occidentalis	No treatment.

951-978	Cottonwood	Open tank method with creosote.
*1-25	Douglas fir	Treated by patent process with Zeta-Meta-Arserite by the Washington Wood Preserving Co. of Seattle, Washington.

* Numbers stamped on top of the post.

TABLE II

Species	Serial No.	No.Posts	Date set out	M.C.	M.Dev.
Douglas fir	1- 15 51-60	25	Jan.7, 1928	15.7	1.6
Douglas fir	16- 30 61- 70	25	Jan.7, 1928	16.3	1.5
Douglas fir	31- 50 71- 75	25	Jan.7, 1928	16.0	2.1
Douglas fir	76-100	25	Feb.2, 1928	18.0	2.6
Douglas fir	101-125	25	Mar.6, 1928	13.8	1.8
Douglas fir	126-150	25	Mar.20,1928	15.1	1.7
Douglas fir	151-175	25	Mar.6, 1928	13.7	2.2
Douglas fir	176-197	22	Mar.6, 1928	12.6	2.6
White cedar tops	198-207	10	April 4,1928	15.7	1.0
Western red cedar	339-363	25	Mar.5, 1929	20.3	1.3
Yew	364-386	23	Mar.5, 1929	15.7	4.2
Cottonwood	387-411	25	Feb.27, 1929	22.4	2.4
White fir	412-426	25	Mar.5, 1929	22.3	2.0
Red alder	437-461	25	Mar.5, 1929	19.6	1.8
Cascara	462-473	12	Mar.5, 1929	8.9	1.8
Maple	474-498	25	Mar.5, 1929	20.5	2.5

Species	Serial No.	No.Posts	Date set out	M.C.	M.Dev.
Douglas fir	499-525 511,512 omitted	25	Mar.5, 1929 Mar.14,1929	13.8	0.9
Western red cedar light	526-550	25	Apr.1, 1929	19.0	1.2
Douglas fir	551-576 561 omitted	25	May 4, 1929	15.8	1.1
Port Orford cedar	577-601	25	May 4, 1929	24.7	3.9
Douglas fir	602-626	25	May 14,1929	14.9	1.4
White oak	628-652	25	May 7, 1929	6.0*	0.5
Douglas fir	653-702	50	Mar.31,1929	15.4	1.1
Douglas fir	703-729 717,728 omitted	25	Feb.6, 1930	13.9	1.5
Douglas fir	730-754 746 omitted 728 added	25	Feb.6, 1930	15.5	0.9
Osage orange	800-825	26	Apr.15,1933	18.6	1.9
Sitka spruce	826-850A	26	Apr.15,1933	15.8	0.3
Madrona	851-875	25	Feb. 6,1930	7.1	0.5
Ash	876-900	25	Mar.19,1930	20.4	1.8
Incense cedar	901-925	25	Mar.19,1930	20.5	2.2
Western juniper	926-947 & 932A 933 A&B	25	Feb.12,1931	23.0	2.0
Cottonwood	951-975	25	Feb. 6,1931	21.4	1.7
Douglas fir	**1- 25	25	Apr.15,1933	14.8	0.5

M.C. is mean circumference
M.Dev. is mean deviation of the circumference
* is diameter instead of circumference
** Numbers stamped on top of post.

RESULTS:

The time elapsed since even the first posts were set out has been too short to allow but few of the posts to fail. There have been sufficient failures in a few of the species, however, to warrent listing. Table III gives the number of failures of three different untreated species.

TABLE III

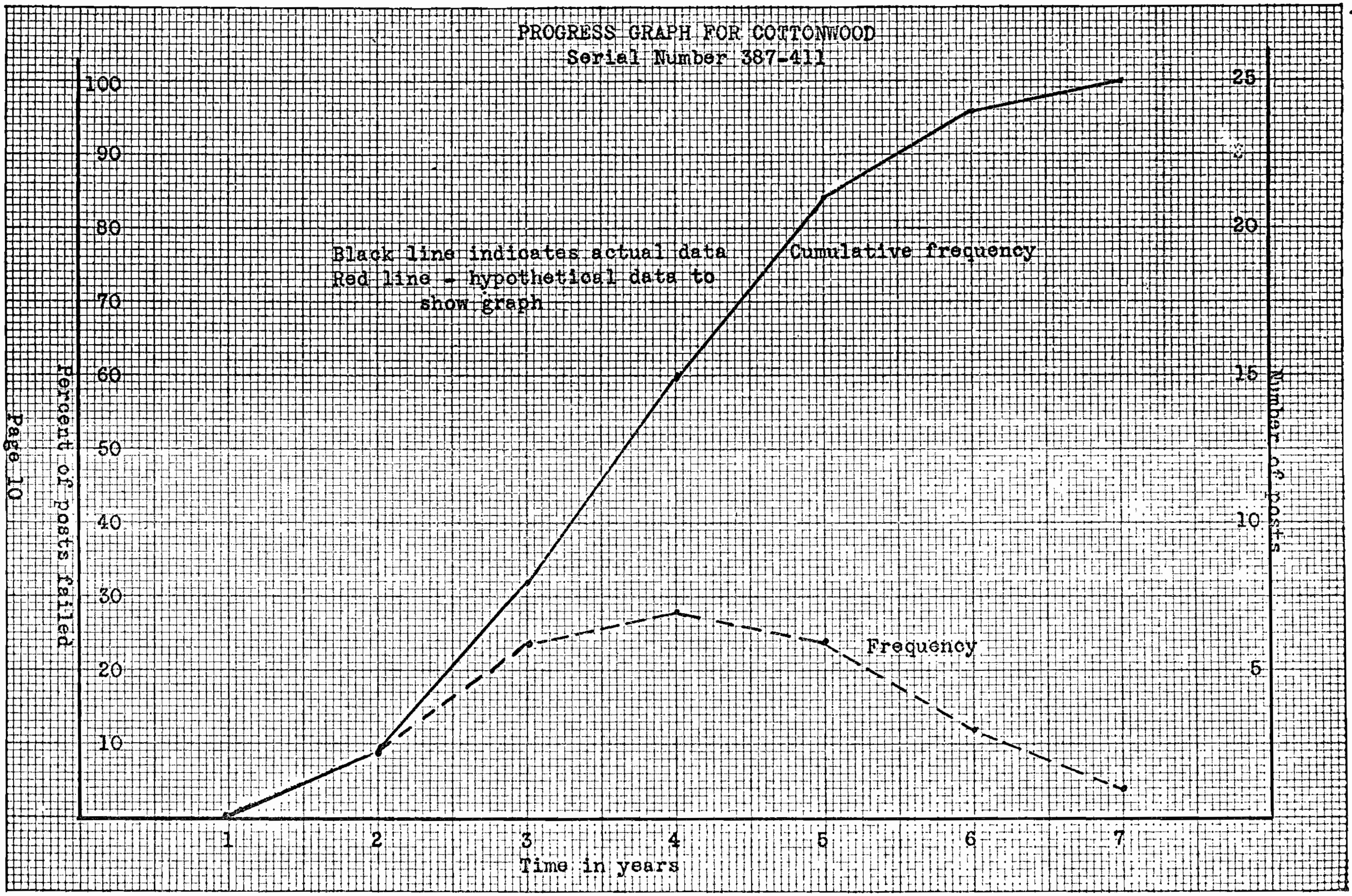
Species	Date set	Number of failures 1930	1931	1932	% of total
Cottonwood	Feb.27, 1929	0	2	6	32
Alder	Mar. 5, 1929	0	1	6	28
White fir	Mar. 5, 1929	0	1	4	20

RECOMMENDATIONS:

In order to facilitate the determination of the status of any particular species or treatment, it is suggested that a progress graph be constructed for each species or treatment as soon as it is judged that there have been enough failures of the particular species or treatment to start the graph.

Such a graph would be of the form of plate I consisting of a frequency and cumulative frequency broken line distribution and pertinent data of the species or treatment.

Also such a graph would be of value in analyzing the data at the termination of the serviceable life of a particular species or treatment. The arithmetic mean alone is a very poor criterion of a sample since it does not tell anything about the spread of the data about the


PROGRESS GRAPH FOR COTTONWOOD
Serial Number 387-411
Black line indicates actual data
Red line - hypothetical data to
show graph
Cumulative frequency
Frequency
Percent of posts failed
Number of posts
Time in years
100
90
80
70
60
50
40
30
20
10
25
20
15
10
5
1
2
3
4
5
6
7

sample. For instance, the fact that the average serviceable life of a species might be ten years does not tell one whether half the posts failed in the ninth year and half in the eleventh or whether the failure was symetrical about ten years with data running from [illegible] to twenty. Likewise, a frequency distribution would locate the mode in reference to the mean. Such a location is important in a skewed distribution as it indicates whether the maximum frequency is less than or greater than the mean.

PUBLICATIONS:

"Posts and Pole Preservation" - T. J. Starker. West Coast Lumberman, Mayl, 1928.

"Salt Treatment of Posts" - C. W. Fox. Timberman, Jan. 1929.

"Learning How to Make Fence Posts Last Longer" - J. C. Burtner, material by T. J. Starker. Oregon Farmer, Mar. 1933.

For a discussion of wood preserving methods, see "Preservation of Wood" - T. J. Starker, a mimeographed pub.

WESTERN YELLOW PINE RACE STUDY

OBJECT:

It was deemed desirable by the Pacific Northwest Forest Experiment Station to determine the adaptability, survival, and rate of growth of the geographical races of western yellow pine (Pinus ponderosa) on various sites in the Pacific Northwest. This study is one carried out in cooperation with that agency.

REFERENCES:

As far as noted, there have been no references in regard to this study published by the Station except the yearly summary of the growth and survival on the various areas. These areas are found at the following other forests:

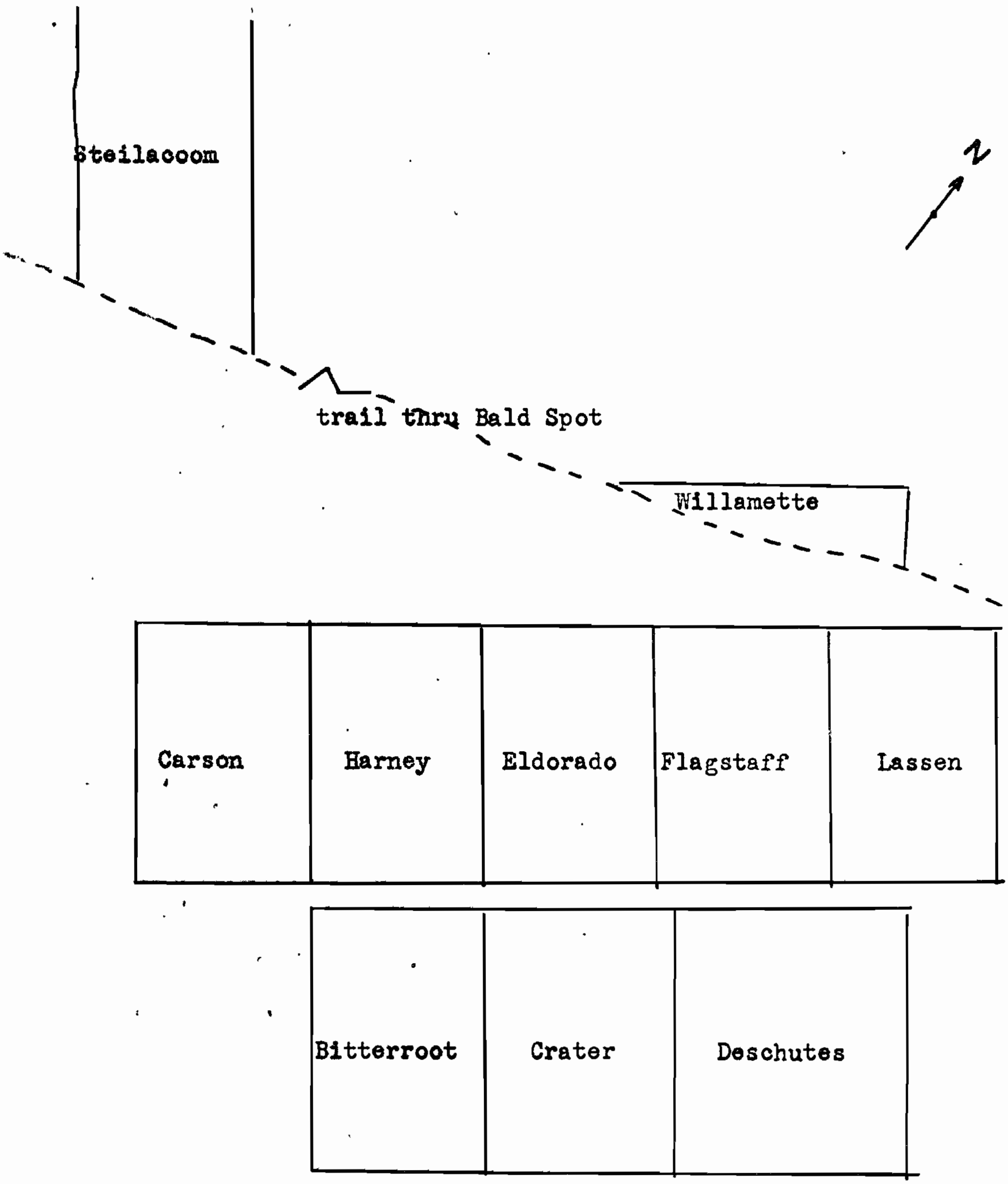
Deschutes National Forest,
Whitman National Forest,
Washington State College,
Pack Forest, and
Columbia National Forest.

PERSONNEL:

The planting at the McDonald forest was done by students in silviculture under the direction of Prof. T. J. Starker on April 3, 1928, April 7, 1928, and in February, 1930.

METHODS:

The planting area lies in forty number 11 of section 16 in the east or lower end of the "Bald Spot." The exposure is southeast and



Showing arrangement of Western Yellow Pine
Race Planting.
(Not drawn to scale)

the slope variable to about thirty percent. The area is an open grassland with scattered Garry oaks, Douglas fir, and poison oak brush.

Seed for the stock was secured from the Experiment Station in 1927 and planted in the nursery. All except the Willamette and Steilacoom were set out in the planting area during the first week in April, 1928. The Willamette and Steilacoom, the seed being received a year later, were set out in Feb., 1930.

The races are named for the locality in which the seeds were collected. They are as follows:

Race	Source	
Bitterroot	Bitterroot National Forest	S.W.Montana
Carson	Carson National Forest	N. New Mex.
Crater	Crater National Forest	S. Oregon
Deschutes	Deschutes National Forest	Cen. Oreg.
Eldorado	Eldorado National Forest	Cen. Oregon
Harney	Harney National Forest	S. Dakota
Lassen	Lassen National Forest	N. Calif.
Flagstaff	Flagstaff National Forest	Cen. Ariz.
Willamette	Willamette Valley	W. Oregon
Steilacoom	Steilacoom Plains	W. Wash.

The stock was planted at a spacing of 6X6 feet in blocks according to the race. The arrangement of the planting area is shown on Plate I. The trees were staked and numbered. Subsequently, a definite one hundred trees were to be measured each year for height and the loss in the hundred would determine the survival. However, the stakes were sooner or later destroyed by frost heaving, gophers, grey diggers, or goats, so that it is now impossible to check on percentage of survival as originally started.

STATUS:

Table I gives the average heights of the different races up to the end of the 1932 growing season.

TABLE I

Race	1928	1929		1930		1931		1932	
	% S.	A.H.	% S.	A.H.	% S.	A.H.	T.M.	A.H.	T.M.
Bitterroot	35	.35	28	*	*	.95	50	1.4	50
Carson	15	.3	10			.7	10	1.2	10
Crater	40	.4	24			1.0	50	1.7	50
Deschutes	42	.4	30			.8	50	1.35	50
Eldorado	28	.4	39			1.2	100	2.1	100
Harney	26	.27	6			.45	8	.85	8
Lassen	28	.3	18			.75	14	1.2	14
Flagstaff	39	.3	19			.65	14	1.05	14
							% S.		% S.
Willamette				.7	94.2	1.1	88	1.85	88
Steilacoom				.6	94.9	.85	88	1.55	88

% S. is % survival.
A.H. is average height in feet.
T.M. is trees measured.
* is no measurements taken that year.

The pine making the best height growth on the other planting areas are as follows:[1]

Planting area	Pines with best growth
Deschutes	Bitterroot
	Eldorado
Whitman	Willamette
Washington State College	Deschutes
Pack Forest	Bitterroot
	Crater
	Deschutes
	Lassen
Columbia	Deschutes

1 Research note by E. L. Kolbe, Pacific N.W.Forest Experiment Station, March, 1932
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DISCUSSION:

It is seen from the tables that the Willamette race, the seed for which came from Linn County just east of Corvallis, is presenting by far the best growth. The great percentage of loss in the first year was not so much due to the vigor of the stock as to the depredations of ground squirrels. An eradication program, aided by the Biological Survey, was started to control the rodents with the result that the Willamette and Steilacoom races were little bothered.

RECOMMENDATIONS:

It is suggested that, despite the almost complete failure of 40% of the planting, subsequent measurements be made each year. The Experiment Station is in need of such data as may be derived from this planting to compare with similar data from the other planting areas representing different site conditions.

OBJECT:

The purpose of the plantation is to determine the fastest growing pine of a group of different species and geographical races of pines.

REFERENCES (Historical):

With the disappearance of virgin stands of timber and a none too rapid replacement of natural reproduction, a need for artificial planting is apparent. The question then arises - Will the present species of trees grow fast enough to meet economic demands? In agriculture, nearly all crop plants are those which, by breeding and selection, have been developed from less desirable wild types. Similiarly then, it should be possible to develop by genetical methods a tree which will grow more rapidly or produce better forest products.

With such an objective, Mr. James G. Eddy[1,2] established the Eddy Tree Breeding Station* in 1925. The station was located at Placerville, California, in a superior western yellow pine region.

The initial investigations covered a great many different kinds of forest trees; however, it was decided to concentrate on only the pines and walnuts. The genus "Pinus" was selected because it is the largest genus of conifers and therefore permitted of more possibilities of crossing to bring out desirable characteristics, because the wood is

1. "A New Enterprise in Forest Tree Breeding", Jour. of Forestry, 27:807.
2. "Breeding Pines for More Rapid Growth", Jour. of Heredity, 19:287.

* Recently the station has been re-named as the "Institute of Forest Genetics."

generally the most useful of any of the conifers, and because it is widely distributed over the United States. The walnuts, "Juglans" were selected because of the possibility of quick development, as sh shown by Burbank, and because of the value of the wood.

To find the rapid growing species or strains of pines, two general methods have been employed: (1) finding the best natural strain, and (2) creating and selecting new strains by hand pollination.

To find the most rapid growing species of pine, seed was collected from over the world and planted, resulting in an accumulation of 87 species of pine. In a given species, there are geographical races which, through development on good sites, produce by heredity superior trees. And also there may be individuals which exhibit a superior growth. The test, however, of such superiority lies not in the reputed superiority of the tree but in the performance of the offspring. To test the offspring, the seed of each tree was planted in four parts of the nursery to allow of variation of site. From each plot, 25 seedlings were mechanically selected and measured, to determine the best female parents.

In order to create new hybrid species or varieties, the investigators have resorted to hand pollination. The procedure has been to select the buds which were believed to be developing to female flowers and cover them with waxed bags. When the pistillate flowers emerged, they were dusted with pollen from the desired parent tree and were again covered until the cone scales closed. When the cones were ripe, they were picked and the seed extracted and planted.

The principal objectives of hand pollination was to bring out hybrid vigor by crossing species or races and to combine good qualities of different species, as for example, western yellow pine and Monterey pine or western yellow pine and slash pine.

To merely test the developed species at the station nursery would hardly be enough of a trial to warrant definite conclusions as to the suitability of a particular pine. Accordingly seed of certain species has been sent to about 20 nurseries in various parts of the United States.

EXPERIMENTAL PLANTING IN THE ARBORETUM:

The seed was received and planted in May, 1929, in the Oregon State Forest nursery. The seed of each lot was sown in a plot 1X4 feet, the plots being arranged according to the vigor rating of the species. Plots were thinned to an average of nine seedlings per square foot in the spring of 1930 and the seedlings were transplanted on March 27, 1930. The entire lot was out planted by the class in silviculture under the supervision of Prof. T. J. Starker on Feb. 2, 1931. Because of the brushy condition of the planting area and the fact that the species were not planted in blocks, some trouble has been experienced in finding all the trees of a given lot to measure them. It is hoped that the difficulty has been remedied this past year when each row was given a permanent stake and label and the rows plotted on a map. It has been the policy to measure each seedling in the planting at the end of each growing season, noting deaths and causes where known.

RESULTS:

The following table shows the results of height measurements during the years 1930, 1931, and 1932. In 1930, the height measurements were taken by picking out an average tree in each lot and measuring it. This rather empirical method may partly explain the apparent lack or loss of growth in some species from 1930 to 1931. Such lack or loss of growth may also be explained by the adjustment from transplanting, by top killing, or by destruction of leaders by rodents.

TABLE I

LIST OF PINE PLANTINGS

Scientific name (Pinus)	Lot	Common name (Pine)	Source
radiata	P-K	Monterey	Monterey Co. Cal.
radiata	Q	Monterey	Mateo Co. Cal.
patula	H	Spreading-leaved	Mexico
halepensis	N	Aleppo	S. France
pinaster	O	Cluster	W. France
pinaster gigantea	A		Italy
caribaea	S	Slash	Lake City, Flor.
taeda	AB	Loblolly	Carthage, N.C.
muricata	J	Bishop	New Zealand
coulteri	H	Coulter	Santa Ana Mts. Cal.
canariensis	Q	Canary	Canary Islands
longifolia	J-D	Long-leaved Indian	Himalayas
insularis	F	Khasia	Burma, India
merkusii	C	Tenasseria	Burma, India
densiflora	K	Japanese red	Jap.Bot.Gar. Tokyo
echinata	X	Shortleaf	Arkansas
sondereggeri F_2	B	Sonderegger hybrid	Greeley Pasture, La
ponderosa	Id-Lew-1-4	Western yellow	Lewis Co. Idaho
ponderosa	Mod-2-1	Western yellow	Modoc Co. Cal.
ponderosa	Eld-23-6	Western yellow	El Dorado Co. Cal.
ponderosa	Eld-4-36	Western Yellow	El Dorado Co. Cal.

TABLE I (Cont'd)

Scientific name (Pinus)	Lot	Common name (Pine)	Source
ponderosa	Eld-30-1	Western yellow	El Dorado Co.Cal.
ponderosa	SDie-2-1	Western yellow	San Diego, Cal.
pon. jeffreyi	Nev-Orm-1-1	Jeffrey	Orasby Co. Nev.
pon. scopulorum	Wyo-Was-1-1	Ry.Mt.West. yellow	Wyoming
schinata x rigida F_2	B	Hybrid	Mont Alto, Pa.
montezumae	M	Rough-branched Mex.	Mexico
greggii	B	Gregg	South Africa
palustris	Z	Longleaf	Carthage, N.C.
sylvestris	AB	Scotch	Finland, parish Kannus
nigra calabrica	O	Corsican	Yugoslavia
lambertiana	P	Sugar	El Dorado Co. Cal.
excelsa	D	Himalayan	Wiener-Neustadt Austria
peuce	E	Macedonian	Yugoslavia

TABLE II

GROWTH DATA

Pinus	Lot	*	H. 1930	T.P. 1930	H. 1931	T.F. 1931	H. 1932	T.F. 1932
radiata	P.K.	10	1.80	36	1.70	10	2.75	21
radiata	Q	10	1.80	36	1.85	21	2.55	31
patula	H	8	.50	36	.65	3	1.00	3
halepensis	N	7	.90	36	.95	12	.90	9
pinaster	O	7	.70	36	***		.90	11
pinaster gigantea	A	7	.50	36	.80	28		
caribaea	S	7	.85	36	.80	11	1.10	11
taeda	A.B.	7	.95	36	1.00	17	1.65	14
muricata	J	6	1.20	36	1.20	30	2.15	30
coulteri	H	6	.90	36	***		1.10	12
canariensis	Q	6	dead					
longifolia	J-D	6	.20	1	dead			
insularis	F	6	dead					
merkusii	C	6	dead					
densiflora	K	5	.60	36	.90	3	1.10	5
echinata	X	5	.70	36	.60	3	1.05	1
sondereggerii F_2	B	5	.80	36	***		1.40	2
ponderosa	Id-Lew-1-4	4	.40	36	.65	30	.85	24
ponderosa	Mod-2-1	4	.40	36	***		.70	22

TABLE II (Cont'd)

Pinus	Lot	*	H.	T.P.	H.	T.F.	H.	T.F.
			1930		1931		1932	
ponderosa	Eld-23-6	4	.65	36	.75	15	1.20	18
ponderosa	Eld-4-36	4	.50	36	.70	12	.90	23
ponderosa	Eld-30-1	4	.35	36	.45	15	.70	22
ponderosa	SDie-2-1	4	.50	36	.60	12	1.00	32
ponderosa jeffreyi	Nev-Orm-1-1	3	.30	36	.50	8	.50	13
ponderosa scopulorum	Wyo-Was-1-1	3	.40	36	.30	7	.45	10
echinata x rigida F_2	B	4	.10	36	dead			
montezumae	M	4	.70	36	1.15	3	1.35	3
greggii	B	4	.75	36	dead			
palustris	Z	3	.07	36	dead			
sylvestris	AB	3	.17	36	dead			
nigra calabrica	O	2	.20	36	***		.60	5
lambertiana	P	2	.12	36	dead			
excelsa	D	2	.12	1	dead			
peuce	E	1	.10	1	dead			

* vigor rating as determined by the station relative to growth in two years.
*** not found that year.
T.P. is "trees transplanted."
T.F. is "trees found."
H. is height in feet.

DISCUSSION:

It will be noted in the table that there is little agreement between the vigor rating determined by the Institute of Forest Genetics and the growth of the trees on the Arboretum. It is significant to note, however, that in each case Pinus radiata exhibited the greatest growth vigor. This is not so remarkable because rapid growth in youth is a characteristic of this particular pine. Nor is ti significant because the quality of the pine does not make it commercially desirable even if it does possess rapid growth.

THE FERTILIZATION OF BLACK LOCUST

OBJECT:

This project was started to determine the value of fertilizers on black locust.

REFERENCES:

The literature is replete with references as to the growth of black locust but there seems to be little on the value of fertilization. Cope[1] expresses the need of data on the growth of black locust in re - gard to soil acidity and in regard to legume inoculation. Studies in Pennsylvania[2] indicate that black locust does well on moist fertile soils or loams.

METHODS:

The area on which the investigation is being conducted is not on the McDonald Forest, but is located west of Corvallis at about 40th and Arnold Way. The tract, owned by Mr. Starker, is on the south side of the road.

The study was started as a project in a silviculture class in the fall of 1930. In the spring of 1929, six rows of 1-0 black locust stock were planted out in the area. During the winter of 1930, the applications of fertilizer were made. On half of each row, the fertilizer was spread on the surface around the tree. On the other half of the

1. Concerning Black Locust in New York - J.A.Cope
   Jour. of Forestry 27:805
2. Black Locust in Pennsylvania, Univ. of Pa. Bull. 236.

row, the fertilizer was deposited in a trench dug around the tree. This trench was about 10 inches deep and about 2.5 feet away from the tree. The following fertilizers were applied:

Row I	(numbering from the east) 0.8 pounds of sheep guano per tree.
Row II	2.5 pounds of agricultural gypsum per tree.
Row III	1.4 pounds of nitrate of soda per tree.
Row IV	1.5 pounds of Swift's "B" Brand per tree.
Row V	0.4 pounds of sulphate of ammonia per tree.
Row VI	Half of the row served as a check row. The other half was divided in two parts, one of which received a half load of cow manure placed on the surface around the trees, and the other received half a load of manure plus 50 pounds of gypsum.

Subsequent measurements have been made of the total height growth at the end of each growing season.

In order to further investigate the value of fertilizers on black locust and because the trees of the original plot have become so large as not to permit of easy measurement, another project was started in April, 1933. At that time, six rows of 50 trees each were planted at the south end of the original plantation. The 1-0 stock was obtained from the Clark-McNary nursery. All the seedlings were carefully graded to obtain uniform stock and the tops were chopped off so that each tree was about the same height (about 6 inches) to start.

Plate I shows the arrangement of the planting and the treatment of each unit of 15 trees. The fertilizer was spread about the trees in a circle of about 2.5 feet in diameter. Posts were set at the north end of each unit to indicate treatment.

The following is an analysis of the fertilizers as determined by

PLATE I

SHOWING ARRANGEMENT OF THE TREATMENTS IN THE BLACK LOCUST FERTILIZATION EXPERIMENT.

S ... N

Row				
1	Check 5 trees	Check 15 trees	Sodium nitrate 2/3 lb. per tree 15 trees	Red Steer 10-6-4 $1\frac{1}{2}$ lb. per tree 15 trees
2	Check	Maple leaves 20 lb. per tree	Check	Ammonium phosphate $1\frac{1}{2}$ lb. per tree Muriate of potash $\frac{1}{4}$ lb. per tree
3	Check	$\frac{1}{2}$# Ammonium sulphate	Check	$\frac{1}{2}$# Calcium cyananid
4	(X)	Check	$\frac{1}{2}$# Ammonium sulphate $\frac{1}{4}$# Muriate of potash	Check
5	(X)	1# Super hydrated lime	Check	$\frac{1}{2}$# Super phosphate $\frac{1}{4}$# Muriate of potash
6	(X)	1# Super hydrated lime	20# Cow manure	20# cow manure 1# Super hydrated lime

(X) soil too wet, trees not used
0 indicates posts
\# indicates pounds applied per tree

the Division of Standards of the Department of Agriculture[3]:

Name	% Nitrogen	% Phosphoric Acid	% Potash
Red Steer 10-6-4	---	---	---
Sodium nitrate	16.47	---	---
Ammonium phosphate	16.54	21.44	---
Muriate of potash	---	---	51.04
Ammonium sulphate	21.56	---	---
Calcium cyanamid	22.15	---	---
Super phosphate	---	18.67	---
Cow manure	0.8(Approx)	---	---

PERSONNEL:

The original study was started by Arthur Rettman as an individual project in silviculture. Measurements this year were made by part of the class in silviculture, Simeri Jarvi, and the writer.

The later project was drawn by Prof. T. J. Starker and Mr. Clayton Long of the American Cyananid Co., which furnished Cyananid and Ammo-Phos for the investigation. The work of setting out the trees and applying the fertilizer was done by the class in silviculture under the direction of Prof. Starker and the writer.

STATUS:

Members of the Soils Department have analyzed soil samples from the area.

The following table presents the summary of the data of the 1932 total height measurements of the original planting.

3. Commercial Fertilizers Sold in Oregon. Mimeographed publication distributed by the Soils Department. Issued by the Department of Agriculture.

Treatment	SURFACE FERTILIZED			DEEP FERTILIZED		
	NO.Trees	AV.H.	s.	No.Trees	Av.H.	s.
Sheep Guano	24	9.2	2.34	21	8.1	2.24
Gypsum	22	9.7	2.66	21	7.8	1.93
Nitrate of Soda	26	10.3	2.32	17	7.2	2.32
Swift's "B" Brand	23	8.5	2.24	33	8.3	2.11
Sulphate of Ammonia	30	8.5	2.23	25	8.8	2.18
Manure	14	11.2	2.29			
Manure and Gypsum	14	9.8	3.16			
Check	29	9.7	2.57			

Av.H. is average height in feet.
s is standard error.

No measurements have been taken on the plot established this spring.

An analysis of soil samples from the tract by the Soils Department is as follows:

Soil type - Amity silty clam loam.
Lime requirement - about 2 tons.
Reaction - ph 5.4
Water soluble potash - medium.
Water soluble phosphate - medium.
Water soluble nitrate - fair.

DISCUSSION:

In studying the data, it is noted that only three of the treatments are accompanied by an average height growth greater than that of the check. Those treatments are manure, manure and gypsum, and nitrate of soda. The ratio of the differences of the mean of the check and the mean of the treatment to the standard deviation of the difference of the samples and the corresponding probabilities are:

Treatment	Diff.	Ratio	Probability
Nitrate of Soda, surface	0.6	.62	.535
Manure	1.2	1.44	.149
Manure and Gypsum	0.1	.08	.936

It is evident that none of the differences are significant.

It is peculiar to note that the means of most of the treatments fall below that of the check. And it is more peculiar to note that these differences are significant in two cases, nitrate of soda, deep, and gypsum, deep. The differences, ratio, and probabilities are as follows:

Treatment	Diff.	Ratio	Prob.
Nitrate of soda, deep	2.5	2.45	.015
Gypsum, deep	1.9	2.0	.046

Both these differences may be considered significant but just why the growth was inhibited, if the difference is due to the characteristics of the sample, is not understood. Considering the whole of the data, it appears that fertilization has little or no value on the growth of black locust.

RECOMMENDATIONS:

In the original study, if the fertilizer were to have exhibited any effect on the trees, such an effect would have surely been evident by this time. Accordingly, it would be a waste of time to continue measurements of the original plot. Measurements of the trees in the project initiated in 1933 should be analysed statistically for proper determination of the significance of any differences which may result.

THE LIBERATION OF DOUGLAS FIR REPRODUCTION

OBJECT:

The object of this study is to determine the effect on the Douglas fir reproduction when the overtopping Oregon White oak was girdled.

REFERENCES:

As far as noted, the literature does not contain any reference to the effect of liberating Douglas fir by girdling overtopping hardwoods. Girdling, as a silvicultural measure, has been practiced in the northeast particularly in the spruce and fir pulp forests. Westveld (1) describes three plots established by the Forest Service in 1905 on one of which heavy girdling of the hardwoods was practiced, on the second, moderate girdling, and on the third, no girdling. At the end of 22 years, the heavily girdled plot had a volume of 902 cubic feet, the moderately girdled plot, 565 cubic feet, and the check plot, 158 cubic feet. Churchill (2) noted that, on holdings of the Finch and Pruyn Paper Co., if the overtopping hardwoods were partially removed, the young conifers often died from the sudden exposure, and if no hardwoods were removed, it required about twice as long for the conifers to reach pulpwood size. Plice and Hedden(3) found that, after the hardwoods were girdled, the annual height growth of balsam fir increased from 4.4 inches to 13.4 inches in five years. The increase in spruce was from 4.8 inches to 12.6 inches at the end of five years.

(1) Girdling Hardwoods to Release Spruce and Balsam fir. J.ofF. 28:101
(2) Girdling Hardwoods to Release Young Conifers. J.of F. 25:708
(3) Selective Girdling of Hardwoods to Release Young Growth of Conifers. J. of F. 29:32.

They attribute the increased leader growth to a gradual increase in available light and to a larger supply of nutrients due to decreased competition and more rapid decay of organic matter.

PERSONNEL:

The initial work was done by the class in silviculture under the direction of Prof. T. J. Starker, in January, 1931. Subsequent measurements were made by C. T. Brown in the spring of 1932 and by Prof. Starker, Simeri Jarvi, and H. A. Fowells in the fall of 1932.

METHODS:

The plots consist of an area about 25 feet by 75 feet in which there are two distinct clumps of Oregon white oak, each overtopping a group of Douglas fir reproduction. On the west half of the area, the oaks were deeply girdled and on the east half of the area the oaks were not girdled. All the Douglas fir reproduction was numbered with an aluminum tags and the total height and internodal distance or yearly growth for the previous five years measured.

The original working plan called for the annual measurement of all the trees on the plot. However, when the data on the original measurements were analyzed, it was found that there was so much variation in the whole sample that any difference in growth between the samples would be found insignificant because of such a variation in the sample. Accordingly in the fall of 1932, twenty-five of the largest trees were selected on each plot. The yearly leader growth of these trees will be analyzed as a measure of the effect of liberation.

Photographs of the two plots are to be taken periodically to serve as another means of comparison.

STATUS:

Table I gives the average measurements of all the trees on each of the plots.

TABLE I

	GIRDLED PLOT		CHECK PLOT	
	M.	s	M.	s
1930 total height	39.2	22.7	25.3	19.3
1931 growth	9.3	5.1	6.6	4.3
1930 growth	8.2	5.2	6.3	3.7
1929 growth	7.7	4.7	6.2	3.9
Number of trees (January 1931)	226		274	

M. is the mean in inches.
s. is the standard error in inches.

Table II tives the summary of the data for the 25 trees selected on each plot in the fall of 1932.

TABLE II

	GIRDLED PLOT		CHECK PLOT	
	M.	s.	M.	s.
1930 total height	73.7	14.5	73.8	20.8
1932 growth	18.2	5.3	15.0	3.7
1931 growth	16.2	3.1	15.0	5.3
1930 growth	15.0	4.1	14.2	4.3
1929 growth	14.0	4.4	14.4	4.9

M. is the mean in inches
s. is the standard error in inches.

DISCUSSION:

Because of the great variation in the sample, the measurements on the plot as a whole will not be considered.

An examination of Plate I will indicate that after the liberation cutting, there is a rapid divergence in the two curves, particularly in the second year after liberation. The more rapid gain in the second year may be explained by the fact that the girdled oaks were not killed the first year and were a little alive even during the second year. Applying the test for the significance of the differences between averages, the standard error of the difference in the 1931 leader measurements is found to be 1.23. The difference between the means is seen to be 16.2 - 15.0 or 1.2, and the ratio of this difference to the standard error of the difference is .98. The probability associated with this ratio is 327 in 1000, a probability not regarded as significant but merely indicative of a difference which might be due to errors of sampling or to the nature of the samples.

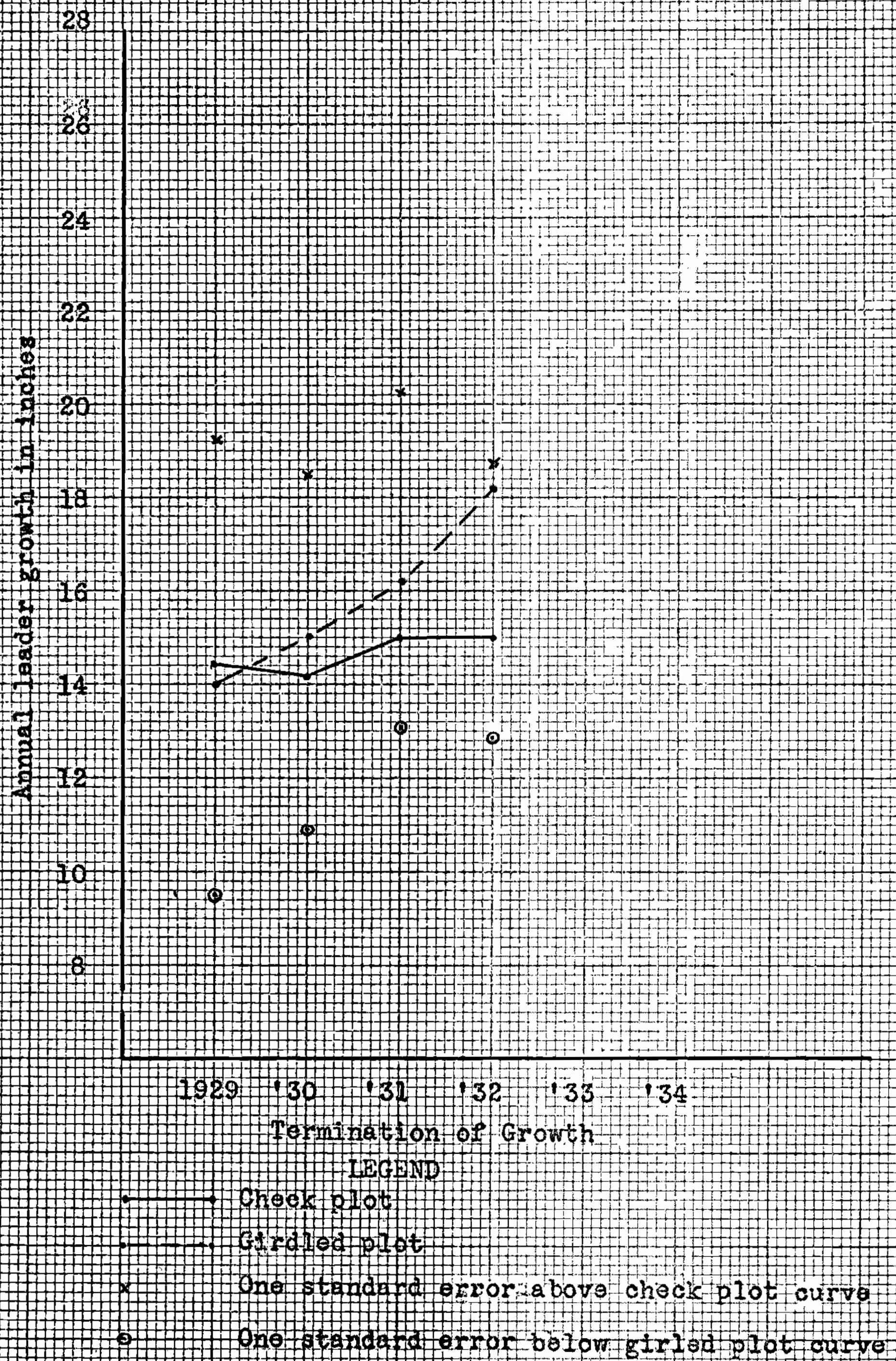
Applying the same test to the 1932 growth data, the standard error of the difference is found to be 1.30. The difference between the means is 3.2 and the ratio of the difference to the standard error is 2.46. The probability associated with this ratio is 14 in 1000, a rather significant probability. Without doubt the difference in the means is due to the nature of the samples, thru their treatment and not due to the variations of sampling.

The reason for the increased growth in the plot on which the oaks were girdled is probably a combination of both more light and more

Liberation Plot

Plate I

Comparison of annual leader growth



moisture during the control period.

RECOMMENDATIONS:

Since there is an evident difference in the growth rate of the two samples, it would be desirable to take a few soil samples from the two plots to see if there is an appreciable difference in the moisture content. It would also be desirable to determine the relative amounts of light that are allowed to fall on the two plots, provided a suitable means of measurement can be found. The data from this plot should be compared with the data to be obtained from the liberation thinning plots established in April, 1933.

SPACING TEST OF DOUGLAS FIR

OBJECT:

The spacing test was started to determine the effect of spacing arrangement, thru its influence on competition, on the growth of field planted Douglas fir.

REFERENCES:

The literature, in so far as the author can determine, does not contain any reference to the results of spacing tests of field planted stock. A similar study is included among the projects of the Pacific Northwest Forest Experiment Station.

METHODS:

The project was started in 1927 by Prof. T. J. Starker with the aid of his class in silviculture. Douglas fir 1-1-2 stock was used for planting, the stock being obtained from Wind River and then grown south of the Forestry building. Sixteen rows, four feet apart, with trees spaced at intervals of four feet in the row, and 16 rows, eight feet apart, with trees spaced at intervals of eight feet in a row, were planted; or a total of 800 trees in the 4X4 spacing and 400 trees in the 8X8 spacing. A year later another plantation was set out in 12X12 spacing but because of poor planting stock and poor planting conditions, survival was so poor as to warrant not considering the remaining trees.

In March, 1933, five growing seasons after the study was started, representative rows in each of the two spacings were selected and 100 trees in each spacing measured for total height and leader growth. This work was done by Prof. Starker and the writer.

Statistical methods as described in the appendix were used to analyze the data.

STATUS:

The following table gives the analysis of the data as found.

	4X4 Total height feet	4X4 Leader feet	8X8 Total height feet	8X8 Leader feet
Mean (M)	6.50	1.48	6.30	1.62
Standard error (s)	1.88	0.34	1.78	0.40
Standard error of mean (S)	0.188	0.034	0.178	0.04

Standard error of the difference of the means of total height 0.259
Standard error of the difference of means of leader growth 0.053

DISCUSSION:

There is little significance attached to the difference between the means of the total heights of the two samples. The standard error of the difference is found to be 0.259, the difference between the means is 0.14, and the ratio between this difference and the standard error is 0.54. The probability associated with this difference is 599 in 1000. The difference might then be regarded as one that might happen more often than the average difference one would expect in sampling.

But the means of the leader growth present a difference that is very significant. The standard error of the difference is 0.053; the difference between the means is 0.14; and the ratio of the difference to the standard error is 2.64. The resultant probability is 62 in 10,000. It is very evident that the difference must be due to the nature of the two samples, which we will assume to be the difference in spacing.

It is interesting to note that while there is not a significant difference in total growth, there is such a difference in the leader growth. This might lead to the conclusion that the effect of spacing is just beginning to be in evidence. If that be the case, then the next total measurements should show a significant difference between the total heights.

RECOMMENDATIONS:

The trees should be remeasured in 2 years, or in the fall of 1934, and the data analysed to see if there is any significant difference between the two spacings.

THE DOUGLAS FIR COMPETITION OR TOLERANCE PLOTS

OBJECT:

In order to investigate the factor of competition for moisture by young Douglas fir reproduction, four plots, two trenched and two not trenched, have been established in a stand of Douglas fir.

REFERENCES:

The question of competition in forest growth is almost as old as the practice of silviculture. Heyer[1], a German silviculturist, propounded the theory that if there was sufficient moisture in the soil, light-requiring species would be able to grow in shade; but he believed that light was the most important factor. Fricke[1] ascribed the lack of vegetation and reproduction on a forest floor, not to insufficient light, but to a lack of soil moisture. He arrived at this conclusion from a study of the vegetation on quadrats which had been trenched and check quadrats not trenched, both under a forest canopy and receiving the same amount of light. Craib[2], in examining the trenched quadrat plots established by Toumey, concludes that:

1. The amount of available soil moisture is greatly increased by the elimination of root competition by trenching. During periods of extreme dryness, there may be two to nine times as much moisture available to the plant in the trenched plots as in the untrenched plots.

2. During the three driest months of the year, July, August, September, the amount of available moisture may fall below that necess-

1. Original articles in German. Reference obtained from 2.
2. Soil Moisture in the Forest. -Craib. Yale Univ. For. School Bulletin 25.

ary to support plant life.

Toumey[3] reports that the increase in the average height of small white pines which had been trenched for the three years after trenching over that for the 5 year period preceding trenching was 337% greater than that of the untrenched pines. In describing the vegetation on trenched and untrenched quadrats under a 60 year old white pine forest, Toumey says that a succession occurred in the plants on the trenched plot. He ascribes this change in vegetation to a greater amount of soil moisture. He indicates that the lack of or poor condition of reproduction in white pine stands is due to inadequate soil moisture at critical periods rather than insufficient light. Notestein[4] notes that Douglas fir will reproduce in a light intensity of 8.5% of full light and that moisture is the critical factor.

METHODS:

Four plots, each 20X20 feet, constituting two treated plots and two check plots, were laid out in a Douglas fir stand, age 60-70 years, site III. The plots were numbered A,B,C, and D. Plots B and C were freed from root competition by digging a trench two feet deep around the plot. Two Douglas fir boards, 1 inch X 12 inches X 20 feet, were placed, edge to edge, in the trench on each side of the plot. The top edge of the top board was just even with the surface of the soil. The

3. The Vegetation of the Forest Floor; Light Versus Soil Moisture. - J. W. Toumey, Proceedings of International Congress of Plant Science 1:575.
4. Climate Characteristics of Forest Types in the Central Rocky Mountains. Proceedings of the American Society of Foresters, 1914. Vol. 1:78.

trench was then filled with soil. In the process of laying out the plots and subsequent work and examinations, care was exercised not to disturb the plots.

There was no reproduction in plots A and B. To have a basis for measuring the effect of trenching, 16 uniform Douglas fir transplants were planted in each plot. The transplants were planted by the slit method and were spaced at intervals of 5 feet. On plots C and D, there was some Douglas fir reproduction which had begun to show the effects of competition. These samplings were numbered with metal tags and measured for total height and annual growth. The trees have been re-measured each year for annual growth and deaths noted. The vegetation and larger pieces of litter on each plot were mapped.

To prevent trampling, a pole obstruction was placed around plots A and B, C and D.

In October, 1932, before any appreciable rain had ended the summer dry spell, soil samples were taken from each of the four plots at the surface and depths of 6, 12, and 24 inches. The moisture content percent by weight was determined. Other soil samples were taken in March, 1933, in order to determine the wilting coefficient of the soil. The wilting coefficient was determined by first finding the moisture equivalent. The moisture equivalent is usually determined by placing the saturated soil in a centrifuge and subjecting it several hours to a force of 1000 gravities. The moisture content of the soil after the process is known as the moisture equivalent. The moisture equivalent may be closely approximated by slowly mixing water with the soil until a point is reached at which the addition of a little more water will cause a film of water to form when the soil is firmed with a spatula. The moisture content of the soil at this point is a close approximation of the moisture equivalent. The moisture equivalent divided by 1.84 gives an approximation of the wilting coefficient, according to the procedure of Briggs and Shantz[5].

PERSONNEL:

The original work of laying out the plots was done in January, 1931, by the class in silviculture under the direction of Prof. T. J. Starker. Subsequent measurements have been made by C. T. Brown and the writer. Moisture determinations were made by S. Jarvi and the author.

STATUS:

NUMBER OF TREES ON PLOT

		January 1931		Spring 1932		Spring 1933	
Plot		Alive	Dead	Alive	Dead	Alive	Dead
A	(planted)	16	0	*3	14	3	14
B	(planted)	16	0	14	2	12	4
C		6	6	5	7	5	7
D		3	5	3	5	3	5

* Small volunteer yew found.

5. "Applications of Wilting Coefficient Determinations in Agronomic Investigations." - L. J. Briggs and H. L. Shantz. Proceedings of the American Society of Agronomy. Vol. 3, 1911.

PERCENTAGE OF SURVIVAL BASED ON TREES ALIVE IN JAN. 1931
(Small yew in Plot A not included)

Plots	Spring 1932	Spring 1933
A	12 1/2%	12 1/2%
B	87 1/2%	75%
C	83 1/3%	83 1/3%
D	100%	100%

AVERAGE ANNUAL GROWTH IN INCHES

Plot	1929	1930	1931	1932
A	--	--	--	2.6
B	--	--	--	2.7
C	1.8	1.6	2.6	3.3
D	1.3	0.9	0.7	2.2

MOISTURE CONTENT OF SOILS AS OF OCT.15, 1932

Plot	Surface	Depth		
		6"	12"	24"
A (not trenched)	13.6%	22.9%	23.6%	-----
B (trenched)	28.6%	33.3%	34.0%	36.5%
C (trenched)	23.0%	25.9%	28.0%	31.0%
D (not trenched)	14.2%	19.0%	21.0%	26.5%

WILTING COEFFICIENT OF SOIL AS DETERMINED
BY DIVIDING THE MOISTURE EQUIVALENT BY 1.84

Samples taken near	Depth		
	3"	12"	24"
Plots A and B	24.4%	22.4%	21.8%
Plots C and D	20.6%	20.0%	23.4%

On May 6 and 9, 1933, the plots were examined for new reproduction and the following numbers of seedlings staked and counted.

Plot A	31 seedlings
Plot B	34 seedlings
Plot C	145 seedlings
Plot D	164 seedlings

DISCUSSION:

On plots A and B, it is significant to note that the survival of the planted stock is only 12 1/2% on Plot A as compared with 75% on Plot B, the trenched plot. However, there does not seem to be much difference in the growth of the seedlings; a statistical analysis of the significance of the difference would not be accurate because of the small size of the sample.

The data from Plots C and D do not seem to indicate very much. The survival percentages have not changed since the first examination. This is probably due to the fact that the trees were already established and those trees that were crowded by competition had already died. The one tree dying on Plot C after the plots were established was in poor condition at the time of establishment. The growth rate is a little higher on trenched plot C than on D, but again the data were so variable and so small as to not be conclusive.

It is significant to note that the moisture content is consistently higher on the trenched plots than on the untrenched plots, and that the moisture content increases with the depth of the soil. It is also worthy of note that the moisture content of the untrenched plots at the first 6 inches was lower than the wilting coefficient, indicating that there was no or little moisture available to the roots at that depth. At the 12 inch depth, the moisture content was close to the wilting coefficient on the untrenched plots, indicating very little moisture. In the trenched plots, the moisture content was consistently higher than the corresponding wilting coefficients.

Observation indicates more vegetation, particularly moss and trailing blackberry, on the trenched plots than on the untrenched plots. Measurements of the amount of vegetation have not been made in as much as the effect on Douglas fir reproduction is considered the important relationship.

The difference in the number of seedlings found on the plots can hardly be due to any difference in moisture at this time of the year. The interesting facts will be the relative number of those seedlings which survive on the trenched and untrenched plots.

The data as noted substantiate the findings of Toumey and others in as far as the effect on survival and vegetation in concerned. However, the data do not agree with the growth relationships. It seems that the increased moisture alone is not enough to stimulate growth of the Douglas fir reproduction. It is very possible that insufficient light may be as important as the lack of moisture in determining the growth of Douglas fir reproduction under a stand of Douglas fir.

RECOMMENDATIONS:

It would be very interesting to compare light intensities and soil moisture contents under the oaks where good reproduction occurs and under the fir where the reproduction is sparse and stunted. This data would necessarily have to be taken during the growing season and at the end of the growing season. Such a study might give more of an indication of the moisture and light requirements of Douglas fir, a fact which must be known before any definite recommendations can be made.

The seedlings staked should be very carefully checked for survival as soon as possible after the summer dry season.

THE PRUNING - THINNING PLOTS

OBJECT:

As a demonstration of how a wood-lot might be improved and as a means of determining the increase in quantity and quality increment, three plots, one pruned, one thinned and pruned, and one check have been established.

METHODS:

The plots are rectangular in shape, being 295 feet by 147.6 feet with an area of one acre. Around each plot, an isolation strip 10 feet wide was laid out; the treatment on the isolation stip is the same as that of the plot. A wire was strung around the boundary of the plots to serve as a means of demarcation.

On the south plot, all the trees were pruned to a height of about 30 feet. This pruning was done with axes and an orchard or pruning saw. Also all dead trees were felled.

The center plot was not treated and thus serves as a check.

On the third plot, a Borggreve thinning was practiced. This thinning consisted of falling the large limby dominants, and suppressed trees. The rest of the trees were all pruned.

On each plot, the D.B.H. of each tree was measured and recorded. Also on each plot, 25 trees were selected and tagged and the diameters breast high recorded. These trees were selected on the basis of the judgment as to which trees would show the greatest increase in volume and value by pruning or pruning and thinning.

A wire line with white markers was strung around the area to demarcate the boundaries of the plots. Also a fire line was dug around the plots.

In computing the volumes, two local volume tables were constructed using an average height curve obtained from the thinning plots of the same site about 300 feet away, and volume tables, as indicated, from U.S.D.A. Technical Bulletin 201, "The Yield of Douglas Fir in the Pacific Northwest."

The volume tables used in determining volume of the plots are as follows:

TABLE I

CUBIC FOOT VOLUME FOR SECOND GROWTH DOUGLAS FIR.

D.B.H. in inches	Volume in cubic feet	D.B.H.	Volume
4	1.30	22	108
5	3.80	23	115
6	6.14	24	128
7	11.5	25	137
8	12.3	26	145
9	15.9	27	153
10	20.1	28	168
11	25.1	29	177
12	31.0	30	185
13	37.5	31	194
14	44.3	32	211
15	51.2	33	221
16	58.4	34	231
17	65.2	35	241
18	75.5	36	249
19	84.0	37	269
20	92.1	38	279
21	100.0	39	289
		40	300

TABLE II

BOARD FOOT VOLUME FOR SECOND GROWTH DOUGLAS FIR
INTERNATIONAL RULE 1/8 INCH KERF

D.B.H. in inches	Volume in board feet	D.B.H.	Volume
7	44	24	902
8	64	25	960
9	89	26	1020
10	120	27	1088
11	151	28	1210
12	195	29	1281
13	244	30	1351
14	292	31	1423
15	344	32	1575
16	394	33	1650
17	453	34	1725
18	522	35	1802
19	582	36	1974
20	642	37	2052
21	693	38	2153
22	747	39	2319
23	798	40	2400

PERSONNEL:

The first two plots were laid out by Francis McCabe and Jesse Hathorn as a silvicultural problem. The third plot, the thinning-pruning plot, was laid out by Prof. T. J. Starker, Harry Godlove, Simeri Jarvi, and the writer.

All diameter measurements were taken by Prof. Starker, Simeri Jarvi and the writer.

The class in silviculture aided in pruning and falling trees as selected.

A crew under hire cut the felled trees into cordwood for $1.25 per cord.

STATUS:

Measurement of the heights of dominant and codominant trees and of the average age of the stand indicates that the area is site III or site index 130 or 140.

The following table gives the pertinent data concerning the three plots:

		PLOTS		
		Pruned	Pruned & Thinned	Check
Number of trees		204	125	158.0
Mean Diameter	B.H. Inches	11.2	15.1	12.0
Basal Area	Square Feet	185.77	199.07	168.46
Volume	Cubic Feet	7,238.23	8,404.06	6,482.32
Volume	Board Feet	47,685.00	53,612.00	43,071.00
TREES CUT				
Number		--	22	--
Mean Diameter	Inches	--	27.8	--
Basal Area	Square Feet	--	98.41	--
Volume	Cubic Feet	--	4,022.00	--
Volume	Board Feet	--	27,231.00	--
Volume (removed)	Cords	--	37.00	--
SELECTED TREES				
Number		25	25	25
Mean Diameter	Inches	13.7	13.2	13.4
Standard Error	of Diameter	1.83	2.81	2.14

DISCUSSION:

The data indicate that on the pruned and thinned plot, it would be possible for the wood-lot owner to cut off, in the form of cordwood, about 50% of the volume but only about 18% of the number of trees. After such a cutting, the trees which are capable of producing quality increment would increase in volume increment; whereas if the area were not cut, the volume increment on the valuable trees would be small relative to that of the large limby dominants.

RECOMMENDATIONS:

The 25 selected trees in each plot should be remeasured after 5 years and the increase in diameter analysed. Also at the end of several five year periods, a quality cruise should be made on the three plots to determine how pruning has changed the quality of the timber in respect to number 1, 2, or 3 logs. A comparison of the relative amounts of the different grades of logs on the three plots should give an indication of the value of pruning.

DOUGLAS FIR THINNING EXPERIMENT

OBJECT:

It was desired to study the effect of thinnings in second growth Douglas fir on the Peavy Arboretum.

METHODS:

Three series of sample plots were laid out, there being a thinned and a check plot in the first series, two thinned plots and a check plot in the second series, and a thinned and a check plot in the third series. The plots are each one acre, horizontal measurement, excepting those of the third series which are 1/2 acre each.

All trees above 2.5 inches D.B.H. on each plot were numbered with galvanized tags. The diameter breast high, and crown class of each tree was determined and enough heights measured to give a good height over diameter curve for each series.

The thinnings were made so as to leave the dominants and codominants where possible and to create as equal spacing as possible. The thinned trees were measured on the ground for content in board feet, cubic feet, and cords.

An isolation strip 50 feet wide surrounds each plot and received the same treatment as the respective plot.

The working plan calls for a remeasurement at the end of each five year period.

Volumes were computed from the average height curve of each plot and the cubic foor and Scribner rule volume tables of U.S.D.A. Technical Bulletin 201.

PERSONNEL:

The plots were established and measurements taken by a class under the supervision of Prof. E. G. Mason in the winter of 1926. In the winter of 1931, the plots were remeasured by students under the direction of Herbert Willison. All the thinned trees were felled in the fall of 1927 with paid labor from the school. All the data noted in this report was organized by Herbert Willison as a senior thesis.

STATUS:

The following tables give the pertinent data of the plots as of the measurements of 1927 and 1932.

CUBIC FOOT VOLUME

Plot	Area Acres	1927	Thinned	1927 Reserve	1932	Growth
1-B	1	7,257	1,651	5,606	6,341	735
1-A	1	8,166	---	8,166	8,787	621
2-A	1	13,229	2,316	10,913	12,210	1,297
2-B	1	16,161	---	16,161	17,442	1,281
2-C	1	12,502	3,248	9,253	10,696	1,441
3-A	.5	3,930	1,741	2,189	2,565	,376
3-B	.5	3,712	---	3,712	4,151	439

BOARD FOOT VOLUME

Plot	1927	Thinned	1927 Reserve	1932	Growth
1-B	30,918	6,566	24,352	28,342	3,990
1-A	35,166	----	35,166	38,263	3,097
2-A	65,578	10,333	55,245	64,763	9,518
2-B	79,938	----	79,938	87,557	7,619
2-C	66,812	16,291	50,521	60,083	9,562
3-A	18,221	7,921	10,300	12,421	2,121
3-B	17,214	---	17,214	19,948	2,734

COMPARISON OF GROWTHS

Plot	% Thinned	% Reserved	1932 % of Reserve	% Growth of original	% Growth of check
1-B	21	79	116	13	129
1-A	--	100	109	9	--
2-A	16	84	117	14.5	125
2-B	--	100	109.5	9.5	--
2-C	24	76	119	14.5	126
3-A	44	56	120.5	11.5	78
3-B	--	100	116	16	--

SITE QUALITY AND AVERAGE AGE OF PLOTS (1927)

Plot	Site Quality	Site Index	Age
1-A & 1-B	III	150	60
2-A & 2-B	III	155	75
2-C	II	170	75
3-A & 3-B	III	155	60

DISCUSSION:

In comparing the figures of the percent of growth based on the original with the respective percentages of thinning, it is evident that there is little relationship between the percentage of thinning and the resultant growth. This is not in accord with findings of Roeser[1] who made thinnings of sapling Douglas firs in the Rocky Mountain region. He found that there was the greatest percent of increment on the plots which had been thinned heaviest. The difference in the two findings may be due to the difference in age of the stands.

There does appear to be a slight relationship between the amount

1. "Effect of Thinning in Sapling Douglas Fir in the Central Rocky Mt. Region." Jacob Roeser. J. of F. 26:1006 Page 60

thinned and the percentage of growth based on the volume of the corresponding check plot. The variation which occurs in the relationship is very likely due to the difference in site quality, as the series 2 plots are of better site than the rest.

Five years is too short a time in which to draw any definite relationship from a study of this kind. The data do show, however, that thinning has materially increased the increment of the plots.

METHODS OF PLANTING

OBJECT:

The object of this investigation is to determine the best method or methods of field planting forest stock and to determine, if possible, how much exposure a transplant can endure and survive.

REFERENCES:

This study is a continuation of a similar investigation carried on at the school of forestry at Pennsylvania State College, by Prof. T. J. Starker, and members of that school. Norway pine (Pinus resinosa) 3 year old plants carefully graded were used for the planting. Results[1] of that study show the following percentages of mortality accompanying the method of planting and the relative rating of the methods from best to poorest with 1 as best after one growing season.

Method of Planting	Mortality %	Rating
1. Cone planting	3.6	1
2. Stock puddled	4.5	2
3. Bunched Roots	12.6	6
4. Slit	10.0	5
5. Roots exposed 15 minutes	9.0	3
6. Roots exposed 30 minutes	17.08	7
7. Roots exposed 1 hour	17.08	7
8. Careful mattock	9.5	4

Cheyney[2] reports that bunching of roots has little effect upon the growth of white pine (Pinus strobus), white cedar (Thuja occidentalis), and blue spruce (Picea pungens) trees. He admits, however, that his sampling and field technique were poor. Toumey[3] says that

1. Personal communication to Prof. T. J. Starker.
2. "The Effect of Position of Roots Upon the Growth of Planted Trees." - E.G.Cheyney Jour. of For. 25:1013.
3. "Seeding and Planting in the Practice of Forestry. J.W. Toumey - John Wiley and Sons, 1916

puddling often does more harm than good. He does not recommend any one method of planting as best, saying that the method is dependent upon the cost and the planting conditions.

METHODS:

The planting methods investigation consists of a series of eight different treatments of the plants. Each treatment was represented by 4 rows of 50 plants, making the series of 8 repeated 4 times. As an added check, the test started in the fall of 1932, was repeated in the spring of 1933. This will give a comparison between spring and fall planting also.

The different methods of planting were as follows:

CONE PLANTING - A hole was dug with a mattock and a cone of dirt built up in the bottom of the hole. Over this cone of dirt, the roots of the seedling were spread and fine dirt then filled in around the roots and firmed with the hands.

PUDDLED PLANTING - Prior to planting, the transplants were allowed to stand in a bucket of mud. The transplants were then planted carefully by digging a hole with a mattock, carefully straightening out the roots, and filling the hole with fine dirt. The dirt was then firmed with the mattock.

BUNCHED ROOTS - Instead of carefully straightening out the roots in the hole dug by a mattock, the planter doubled the roots back upon thenselves one half their length and then covered them with fine dirt.

SLIT PLANTING - A slit was made with a heavy steel dibble. The roots were placed in this slit and the earth pressed around them by making another slit 3 or 4 inches away and shoving forward on the dibble.

ROOTS EXPOSED - In this category are three series, one with the roots exposed 15 minutes, another exposed 30 minutes, and a third exposed 1 hour. The plants were covered at the end of the allotted time and then carefully planted with a mattock.

MATTOCK PLANTING - A hole was dug with a mattock and the roots extended into this hole along one side. The hole was filled with fine dirt and firmed with the heel or the mattock.

The stock used for planting was 1-1 Pinus ponderosa from the Oregon forest nursery. The transplants were carefully graded and the roots pruned till they were about 6 inches long. Each row was labelled with an embossed tag as to the treatment received.

The planting area lies just north of the Oregon forest nursery. The timber was removed some years ago except an occasional oak. Since then, the area has been occasionally grazed. The soil may be described as an Aiken clay loam.

Before planting, the sod was removed from an area about 2 feet square.

At the time of planting, the relative humidity was determined with a sling psychrometer. At the fall planting, October 20, 1932, the air temperature was 67°F. and the relative humidity 82%. At the spring planting, April 10, 1933, the air temperature was 53°F. and the relative humidity 56%.

PERSONNEL:

The planting was done by the class in silviculture under the direction of Prof. T. J. Starker, assisted by the writer.

STATUS:

The plantings have not been examined as yet, due to the fact that the late spring has retarded growth. Examinations will be made late in May and again in the fall to check survival.

RECOMMENDATIONS:

It would be very desirable to analyse the data by some statistical means to see how significant the results found really are. This could very easily be done by assuming that the proportion of the deaths would be equal to the probability of failure (q) and the proportion of the living be taken as the probability of success (p), then the standard deviation of the proportion of failures, or dead, would be : S.D. equals $\pm\sqrt{\frac{pq}{n}}$ where n is the number in the sample. It would be necessary to find the standard deviation of the proportion of the dead for each treatment.

To compare the difference between treatments then, find the standard deviation of the difference by the formula: Standard deviation of a difference, in the case of attributes, equals $\pm\sqrt{\overline{S.D.}_x^2 \text{ plus } \overline{S.D.}_y^2}$ where $S.D._x$ and $S.D._y$ are the standard deviations of the proportion of the dead of the treatments being compared. Then find the difference between the proportion of the dead of the two samples. To determine how significant the difference is, find the ratio of the difference to the standard deviation of the difference. If the ratio exceeds 3, it is very probable that the difference is not due to fluctuations of sampling. The probability associated with the ratio may be found approximately in the appendix.

Such a procedure seems rather too complicated to merely enable one to say that a difference is or is not significant; but if correct statistical analysis is followed, the conclusions are much less apt to be questioned.

THE NATURAL REPRODUCTION OF DOUGLAS FIR

OBJECT:

As a silvicultural question which must be answered before any system of management can be devised, it is necessary to find out under what conditions Douglas fir (Pseudo-tsuga taxifolia) will reproduce naturally. To partially answer this question, there have been established three different series of plots which are being examined for seedlings.

REFERENCES:

Necessarily there must be a source of seed before there can be any reproduction. Concerning the survival of seed trees on logged over areas, studies indicate[1] that the losses of seed trees may vary from 9 to 78%, partially dependent upon whether or not the area had been burned. Isaac[2] reports that from a heavy seed crop, the bulk of the seed will fall at a distance of 100 to 200 feet from the block of remaining timber but that 8000 sound seed per acre might be found at a distance of 900 feet from the edge of the timber.

Hoffman[3] theorized that the abundant reproduction occurring after the Yacolt burn was due primarily to the seed stored on the duff. Isaac[4] has refuted this theory, after several years of experimentation with seed stored in the duff.

1. Research Notes of the Pacific Northwest Forest Experiment Station.
2. Seed Flight in the Douglas Fir Region. - L. A. Isaac. Jour. of For. 28:492.
3. Natural Regeneration of Douglas Fir. U.S.D.A.Bull. 1200.
4. Personnel communication with Mr. Isaac of the Pacific Northwest Forest Experiment Station.

Concerning the establishment and survival of reproduction, Roeser[5] reports that under three different methods of cutting, namely: clear cutting, selection cutting, and shelterwood cutting, Douglas fir reproduction was far superior on the shelterwood plot. The superiority was evident in both the percentage of survival and the height growth of the seedlings. Notestein[6] indicates that Douglas fir will reproduce successfully in a forest with a light intensity of 8.5% of full light.

After 5 years of study on the regeneration of Douglas fir, Isaac[7] concludes that satisfactory reproduction will occur only under slightly shaded conditions, expecially on areas which have been severely burned. Alexander[8], studying reproduction in the Grays Harbor region, also states that germination and survival are best in slightly shaded areas.

METHODS:

As noted before, three series of plots have been established to study the conditions under which reproduction of Douglas fir will occur. These plots are known as the Douglas fir succession plots, the reproduction-slash plots, and the bald spot reproduction plots. Each of these will be considered.

5. A Study of Douglas Fir Reproduction Under Various Cutting Methods. J. Roeser. Jour. of Ag. Res. 28:1233.
6. Climatic Characteristics of Forest Types in the Central Rocky Mountains. Bates, Notestein, and Keplinger. Proceedings of the Soc. of Amer. For. 1914. Vol.1:78.
7. Unpublished bulletin on Douglas Fir Reproduction - Leo A. Isaac. Bulletin in manuscript.
8. Cooperative Forest Study of the Grays Harbor Area - Western Forestry and Conservation Association.

The Douglas Fir Succession Plots.

OBJECT:

These plots were established in order to observe the rate at which Douglas fir becomes established after a burn.

METHODS:

There are twelve plots in the series, each plot being 25X25 feet. The plots are laid out traversing a severe burn occurring as the result of slash fires in 1930. The plots are spaced at a distance of 250 feet from each other and thus represent a traverse of plots 2750 feet long extending throughout the burn.

The plots have been examined each year and the vegetation noted but the reproduction was not staked, so it could be identified and checked on the succeeding examinations. This year all reproduction found on the plots was staked with a small white tipped cedar stake.

PERSONNEL:

The plots were laid out by Horace Cooper and John Philbrich in the winter of 1930-31. Examinations this year were made by the writer on May 6.

STATUS:

Following is the number of seedlings found on the plots. The seedlings found represent a stocking of only 216 seedlings per acre.

Plot	Old Seedlings	1933 Seedlings
1	0	0
2	0	0
3	0	0
4	0	3
5	1	0
6	0	1
7	0	2
8	0	0
9	0	1
10	1	4
11	5	9
12	0	8
Total	7	28

The Reproduction-Slash Plots.

OBJECT:

These plots were established as a means of determining how the method of slash disposal affected the reproduction of Douglas fir.

METHODS:

An area 4X4 chains square was laid off in the slash resulting from logging in 1932 in which small and limby trees were left. This area was subdivided into 16 one chain square plots. This made four series of plots with 4 plots in each series. On one series, the slash was left undisturbed. On a second series, the slash was raked off the plots and piled along the edges. On a third series, the slash was broad cast burned. On the fourth series, the slash was piled and burned. Plate I shows the arrangement of the plots. A five strand barb wire fence was constructed around the plot to keep out sheep and goats. Seedlings will be staked in a strip 6.6 feet wide thru each plot.

SHOWING ARRANGEMENT OF
REPRODUCTION SLASH PLOTS

NE SE

Slash left	Slash raked clean	Slash broadcast burned	Slash piled and burned
trail Raked clean	Left	Piled and burned	Broadcast burned
Broadcast burned	Piled and burned	Left	Raked clean
Piled and burned	Broadcast burned	Raked clean	Left

NW SW

$1\frac{1}{2}$ inches equal 1 chain.

PERSONNEL:

The plots were laid out in 1931-32 by the class in silviculture under the direction of Prof. E. G. Mason. Examinations in the spring of 1933 will be made by the class in silviculture under the supervision of Prof. T. J. Starker and the writer.

STATUS:

Because of inclement weather, the plots have not been examined at the t~~k~~ime of this writing.

THE Bald Spot Reproduction Plots.

OBJECT:

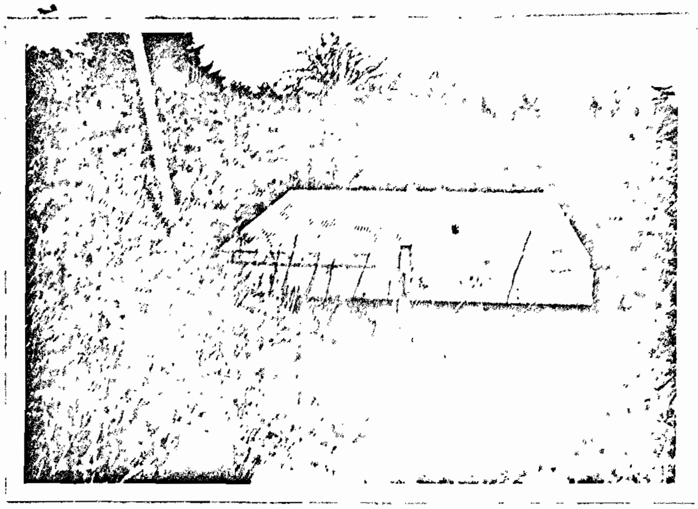
The plots were established to determine if possible why the "bald" area or grass covered area does not reproduce to Douglas fir.

METHODS:

Across the upper end of the "bald" spot lying in section 36, 8 mil-acre plots were established. On four of these plots, all the grass sod was removed with a shovel and the dirt loosened up so as to present a good germination bed. Adjacent to each of these plots is a check plot representing the natural conditions.

A seed trap was placed between each two plots, there being three seed traps. These traps present a surface exposed of 3.97X3.87 feet and represent 1/2829 of an acre.

During the year, seed was collected from the traps and viability found by the cutting test.



Showing the seed trap in position.

The plots have been examined periodically since the beginning of germination and seedlings staked with white tipped cedar stakes.

PERSONNEL:

The plots were established and the seed trap placed in position on Oct. 12, 1932, by Simeri Jarvi and the writer. Subsequent examinations have been made by Prof. Starker and the writer.

STATUS:

The following table gives the total amount and number of viable seeds as found in the three seed traps.

Date examined	Trap 1		Trap 2		Trap 3	
	Total	Viable	Total	Viable	Total	Viable
Oct. 19, 1932	2	1	13	10	1	0
Dec. 3, 1932	2	2	18	9	2	1
Dec. 22, 1932	18	7	42	15	18	8
Mar. 21, 1933	7	0	52	14	6	0
Apr. 15, 1933	15	3	46	12	7	1
May 9, 1933	3	0	8	2	3	1
Totals	47	13	179	60	37	11

Total number of seed found - 263
Total viable seed - - - - - 84
Viable seed fall per acre 40,922 (based on seed fall in traps).
Viable seed per mil-acre plot 41 (based on seed fall per acre).

SEEDLINGS FOUND ON THE PLOTS AS OF MAY 9, 1933

Plot 1	Plot 2	Plot 3	Plot 4
1	1	1	1
Check 1	Check 2	Check 3	Check 4
0	0	1	0

Indicated seedlings per acre according to treated plots 1000
Indicated seedlings per acre according to check plots 250

DISCUSSION OF DOUGLAS FIR REPRODUCTION:

The examinations of the plots so far do not indicate the establishment of a good stand of reproduction even though the past seed year was a good one. On one of the tolerance plots, reproduction was counted at the rate of 18,000 seedlings per acre, indicating an enormous quantity of seed produced. The poor reproduction of the succession plots may be due to two causes: (1) the seed source is too far away, and (2) the area has been heavily grazed by sheep and goats.

The poor establishment of seedlings in the bald spot plots may be due to the depredations of mice and birds. Since the plots are bare, seed and seedlings would be all too evident to mice or birds. Certainly enough seed fell to produce more seedlings than have so far appeared.

Of course, germination has not stopped yet and it is too early too draw any conclusions; but it is known that those seedlings which survive must have an early germination. Thus they develop a longer root system and a more hardened stem before the critical period occurs in the summer. So it is the early germinating seedlings in which the most interest lies.

RECOMMENDATIONS:

Obviously, the plots should be examined at the end of the summer and all deaths and causes of deaths noted. Very often the cause of death may be determined by the condition of the seedling if it can be found. Thus, if a seedling is erect but dried out, drouth is probably the cause. But if the seedling is tipped over with a constriction at the base, the cause may be either heat lesions or dumping-off.

Since the plots will be examined each year for new reproduction, it would be convenient to have some readily apparent means of recognizing the time when the seedlings were staked. This may be done by using a combination of colors on the stakes, as white for 1933, red and white for 1934, blue and white for 1935 etc. The white base is necessary as it makes the stake much more conspicuous and furnishes a good base for the other color. Quick drying enamels have been used with great success by Isaac of the Experiment Station.

Since a good seed year occurs so seldom, every effott should be made to check closely the seedlings which have been staked.

GENERAL SUMMARY OF THE STUDY

An effort has been made to organize and summarize the more important investigations conducted by classes in silviculture principally on the Peavy Arboretum and the McDonald Forest.

THE POST FARM

Failures of the untreated cottonwood, alder, and white fir posts indicate their unworthiness for fence post material.

WESTERN YELLOW PINE RACE STUDY

Of the various pines, the Willamette race of Pinus ponderosa has shown the best growth.

EDDY TREE BREEDING PLANTATION

The two lots of Pinus radiata have exhibited the greatest growth.

FERTILIZATION OF BLACK LOCUST

By statistical analysis of growth data on check plots and plots treated with different fertilizers, it has been shown that fertilization of black locust has no apparent value.

THE LIBERATION OF DOUGLAS FIR REPRODUCTION

There is an indication that the girdling of the overtopping oaks has been accompanied by an increase in the rate of growth of the underlying Douglas firs over that of the check plot.

SPACING TEST OF DOUGLAS FIR

The leader growth of the 8X8 spacing is significantly greater than that of the 4X4 spacing.

DOUGLAS FIR COMPETITION PLOTS

Trenching has affected the survival of the planted Douglas fir but has not apparently stimulated the height growth. A remarkable difference has been found in the moisture content of the trenched and untrenched plots at the end of the dry season.

PRUNING- THINNING PLOTS

A demonstration has been made of how a wood-lot might be improved with supposed consequent increase in quantity and quality.

DOUGLAS FIR THINNING

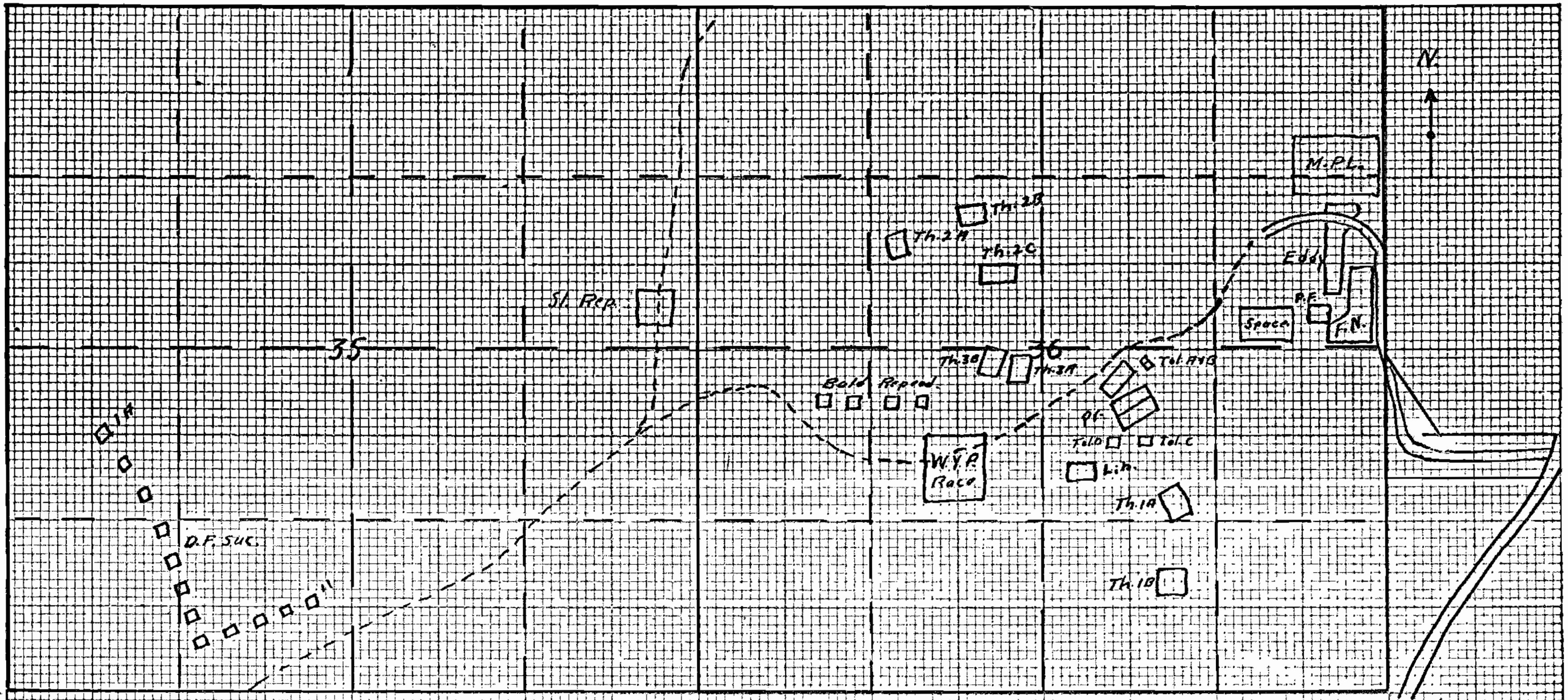
The thinned plots have shown generally a greater per cent of increase than the check plots.

METHODS OF PLANTING

An attempt has been made to determine the effect of different methods of planting on the survival of Pinus ponderosa. No results have been obtained.

DOUGLAS FIR REPRODUCTION

An abundant seed year has apparently not resulted in the establishment of seedlings on the succession plots or the bald spot plots. Remarkable seedling counts have been found on the tolerance plots.



Sketch Map Showing Approximate Location of Plots - McDonald Forest - Sec. 35 and 36

NOTATION

D.F.Suc.	- Douglas fir succession plots	Th.1-3	- Thinning plots
Sl.Rep.	- Slash reproduction plots	Bald Reprod.	- Bald spot reproduction plot
Tol.A-D	- Tolerance plots	Lib.	- Liberation plots
M.Pl.	- Methods of planting	W.Y.P.Race	- Western yellow pine race study
Pr.	- Pruning plots	Eddy	- Eddy tree breeding plantation
P.F.	- Post farm	F.N.	- Forest nursery
Space.	- Douglas fir spacing		

Plots are not drawn to scale

DEFINITIONS AND FORMULAS OF STATISTICAL TERMS

In dealing with quantitative data, as in forest investigative work, it is necessary to have some means of describing a group of data, some means of comparing the characteristics of that data with the characteristics of other data, and some means of measuring the accuracy of the data as sampled. In the following description of statistical terms or methods, the writer does not intend to write a discourse on the derivation or application of such terms but to set forth the formulas used in the thesis in order that future data on the problems may be treated in the same way.

Methods of statistics deal with quantitative data alone but this data may arise in two different ways. In the first place, the presence or absence of some characteristic may be noted and the numbers which do or do not possess the characteristic are counted. Such are attributes. In the second place, the actual magnitude of some variable character may be measured. Such are variables.

FREQUENCY DISTRIBUTION - In a group of data, the observations are classified in certain definite classes which are at equal intervals from each other. These classes increase in size from one end of the scale to the other. The number of times any one observation occurs is known as its frequency. The manner in which the observations are distributed over the successive equal intervals of the scale is the frequency distribution of the variable.

CUMULATIVE FREQUENCY DISTRIBUTION - This may be described as a distribution in which the frequency of any class is represented by its own frequency plus the combined frequencies of all classes preceeding it.

MODE - In a frequency distribution, the mode is that item accompanied by the greatest frequency.

ARITHMETIC MEAN - The arithmetic mean or arithmetic average is the sum of the products of each item multiplied by its frequency, the sum being divided by the total frequency. In notation form:

$$M \text{ equals } \frac{1}{N} \sum_{1}^{n} X_i f_i, \text{ where}$$

M denotes the mean;
N denotes total frequency;
$\sum_{1}^{n}$ denotes a summation;
X_i denotes any item; and
f_i denotes the frequency of X_i.

MEAN DEVIATION - This is the mean of the deviations of the items from the arithmetic mean. In notation form,

$$M.D. \text{ equals } 1/N \sum_{1}^{n} |X_i - M| f_i, \text{ where}$$

N denotes total frequency
$\sum^{n}$ denotes a summation;
$|X_i-M|$ denotes the numerical or absolute deviation of an item from the mean; and
f_i denotes the frequency of X_i.

STANDARD DEVIATION - This is the square root of the mean of the squares of the deviations of the items from the arithmetic mean. In notation form:

$$S.D. \text{ (or } \sigma\text{) equals} \pm \sqrt{1/N \sum_{1}^{n} (X_i - M)^2 f_i}, \text{ where}$$

S.D. denotes the standard deviation;
N denotes total frequency;
$\sum_{1}^{n}$ denotes a summation;
(X_i-M) denotes the deviation of an item from the mean; and
f_i denotes the frequency of X_i.

STANDARD ERROR:- It can be proved[1] that if N-1 is substituted for N in the formula for the standard deviation, the result gives a more accurate measure of dispersion than the standard deviation. Such a substitution is of importance in small samples but in large samples there is little difference because of the relatively small difference between N and N-1. The resultant descriptive measure is known as the standard error. In notation form:

$$s \text{ equals } \sqrt{(1/N-1)\sum_{1}^{n}(X_i - M)^2 f_i}, \text{ where}$$

s is the standard error;
the other symbols are in the standard deviation.

STANDARD ERROR OF MEAN - This is the standard error of a distribution of means. It can be proved[1] that

$$E \text{ equals } s/\sqrt{N}, \text{ where}$$

E denotes the standard error of the mean;
s denotes the standard error of a frequency distribution; and
N denotes the total frequency of the frequency distribution.

PROBABLE ERROR - This is equal to .6745 times the standard error and defines a measure, in a normal distribution, which, added to and substracted from the mean, defines a range including half the total frequency.

STANDARD DEVIATION OF THE NUMBER OF SUCCESSES - If a number of samples are taken with a number of events in each sample, the standard deviation of the number of successes is equal to -

$$S.D. \text{ equals } \sqrt{npq}, \text{ where}$$

S.D. denotes the standard deviation of the number of successes in n events;
p denotes the probability of success;
q denotes the probability of failure; and
n denotes the number of events.

STANDARD DEVIATION OF THE PROPORTION OF SUCCESS - This may be shown

S.D. $\pm\sqrt{\frac{pq}{n}}$, where

S.D. denotes the standard deviation of the proportion of successes; and

p, q, and n, as shown before.

SIGNIFICANCE OF A DIFFERENCE - In determining the significance of the difference between two means in the case of variables, the standard deviation of the difference is required. The standard deviation of the difference may be proved[2] to be equal to $\pm\sqrt{\frac{S.D._1^2}{N_1} \text{ plus } \frac{S.D._2^2}{N_2}}$, where $S.D._1$ and $S.D._2$ are standard deviation s of the frequencies in question and N_1 and N_2 are the respective total frequencies. If the standard error is used in place of the standard deviation, the formula becomes $\pm\sqrt{\frac{s^2}{N_1} \text{ plus } \frac{s^2}{N_2}}$ or $\pm\sqrt{E_1^2 \text{ plus } E_2^2}$ since E equals $s/\sqrt{N}$.

In the case of attributes, the standard deviation of a difference is equal to the square root of the sum of the squares of the standard deviations of the two groups of data in question. In notation form, it is equal to $\pm\sqrt{\overline{S.D._x}^2 \text{ plus } \overline{S.D._y}^2}$, where $S.D._x$ and $S.D._y$ are equal to the standard deviations of the two groups of data.

It is then necessary to find the ratio of the difference between the two means, M_1 and M_2, and the standard deviation of the difference. As this ratio increases, the probability of finding two means with such a deviation decreases. Hence as the ratio increases, the difference between the means becomes more dignificant and the difference may be ascribed to characteristics of the samples rather than to fluctuations in sampling. Following is a table showing the probabilities associated with certain ratios of the difference of the mean to the standard deviation of the difference.

Ratio	Probability	Odds
0.6745	.500	1 to 1
0.75	.453	1.2 to 1
1.00	.315	2.2 to 1
1.25	.211	3.7 to 1
1.50	.134	6.5 to 1
1.75	.080	11.5 to 1
2.00	.047	20.3 to 1
2.25	.024	40.6 to 1
2.50	.013	76.0 to 1
2.75	.006	165.7 to 1
3.00	.0027	369.3 to 1
3.50	.000466	2,140.6 to 1
4.00	.000064	15,624.0 to 1

Odds are computed by substracting the probability from 1 and dividing the result by the probability.

It is seen that if the ratio were .6745 the probability is 50% that there would be such a difference between the samples, or the odds are 1 to 1. Whereas if the ratio were 3.00, the probability is .0027 and the odds are about 370 to 1. A difference is usually considered significant if the ratio is 3 or greater, although a ratio of 2 may be used as a limit of sampling fluctuations.

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SAMPLE PLOTS IN SILVICULTURAL RESEARCH

Condensed from mimeograph report by Forest Service, June, 1932.

PURPOSE AND USE OF SAMPLE PLOTS.

INTRODUCTION:

Sample plots are of two kinds, permanent and temporary.

Sample plots are used (1) when experimental work is to be done on a limited area so that the results may apply to a whole forest type or region, and (2) when data are needed on areas too large to be measured entirely.

The establishment of permanent sample plots is only the beginning of the job. Plots should be so established that the re-measurements are distributed over the year.

NUMBER AND DISTRIBUTION OF PLOTS:

If the whole of an area is to be sampled, plots should be mechanically spaced, with direction of lines of plots considered.

In treated and control plots, less reliance should be placed on few plots and refined measurements, and more on wider extension of work and replications. Plots should be found as similar as possible before treatment. The number of replications may be increased if the plots are subdivided. Treatment should be recorded during the dormant period. "No treatment" is a special case of treatment.

SIZE OF PLOTS:

Generally a plot should be large enough to contain 100 trees at the end of the experiment.

It is advantageous to establish plots which are even multiples or simple fractions of an acre.

Sample plot areas should be measured horizontally and the dat a expressed in terms of horizontal areas.

Subplots, to be studied intensively, should be small enough so that all parts of them can be reached from outside the boundaries. The square milacre (6.6 X 6.6 feet) is frequently used.

SHAPE OF PLOTS:

Plots should be compact in shape, generally with the length not more than 2.5 times the width.

Rectangular plots are preferred.

Circular plots are convenient if the plots are temporary and one man is doing the work.

ISOLATION STRIPS:

In order that conditions may be the same at the edges of a plot as in the interior, the plot should be surrounded by an area treated in the same way that the plot is treated. Such a strip is an isolation strip.

PLAN OF WORK

A detailed plan of work should be written before the field work of plot establishment is started.

The plan should include a clear cut, definite statement of the purpose of the plot and a set of definitions; should state what data are to be gathered; should outline the procedure; and should present a systematic scheme for recording the data.

PLOT ESTABLISHMENT

LOCATION OF THE STAND:

The stand in which plots are to be located must be (1) representative of the area to which it is intended the results of the experiment will apply; (2) fulfill all the conditions needed to carry out the purpose of the study; (3) be assured protection throughout the life of the experiment; and (4) be readily accessible during the experiment.

LOCATION OF PLOTS WITHIN THE STAND:

Plots should be located well within the stand chosen for them.

SURVEYING AND DEMARCATION OF PLOTS:

The accuracy of all data based on an area basis as derived from a sample plot depends on the accuracy of the survey of that plot.

The smaller the plot, the more accurate should be the survey.

When trees are on the line, those with more than half their diameter at the stump inside the plot, should be counted in. Absolute "line trees" should be alternately in and out.

A complete set of notes should be kept of all surveying in connection with plot establishment.

The plot boundary, corners, subdivision stakes, and stations should be permanently and conspicuously marked.

Each sample plot or group of plots should be referenced to some permanent and readily definable object or point by a surveyed traverse.

At least two maps should be prepared. The first should be a general location sketch map and the second a detailed map of the plot or plots series.

NUMBERING INDIVIDUAL TREES AND MARKING THE BREAST-HIGH POINT:

For trees beyond the reproduction stage, the identification is made easy by nailing a numbered metal tag to the tree or by painting the number on its bole.

Durable nails should be used and they should not be driven deeply into the wood. Enough nail should protrude to allow for radial growth up to the time of the next measurement.

All nails and tags should be removed from abandoned plots.

In painting numbers, a durable conspicuous paint should be used.

The trees on a plot should be numbered in a plan wise manner.

The breast height point at which all measurements of diameter are to be made, should be marked on each numbered tree.

Trees too small to bear painted figures or nailed tags may be numbered by markers stuck into the ground or by tags attached to the tree with soft durable wire.

COLLECTION OF DATA ON SAMPLE PLOTS

FIELD NOTES AND FORMS:

All field records should be legible and permanent. Printing is usually more legible than handwriting.

Measurements should be recorded in an orderly way on forms provided.

TREE MEASUREMENTS:

The standard point for the measurement of diameter breast high if 4.5 feet above the average ground level.

The diameter tape is the standard means of measurement.

The D.B.H. should ordinarily be measured to the nearest .1 inch.

The total height of a standing tree is usually defined as the vertical distance from a plane drawn through the acreage ground level at its base to a plane drawn through its tip.

The Abney level and the Forest Service hypsometer give the most reliable values for any instrument requiring a reasonable amount of time and care in manipulation.

In determining the total age of a tree from the ring count, account must be t aken off the years required for the tree to reach the height at which the rings were counted. This period may be determined by a seedling growth study.

REPRODUCTION MEASUREMENTS:

Usually, height alone is measured on reproduction.

A measuring stick marked in feet and tenths should be used.

SOILS:

On long time plots, it may be desirable to follow the change in soil profiles. In such cases, a soil pit should be dug and the soil profile mapped.

DETAILED PLOT MAPS:

If it is necessary to make a map showing all numbered trees on a plot, the work may be simplified by dividing the plot into squares by string and then measuring the distance from a corner to each tree in the square, thus obtaining the coordinates of the tree. The work may also be simplified by a plane table and alidade, or with a traverse board.

PLOT DESCRIPTION:

All the pertinent data concerning the plot as a whole should be ascertained and recorded. Such data would include the plot designation and location, date of establishment, dimensions and area, names of persons establishing plot, forest description, and history of the stand.

PHOTOGRAPHS:

Good photographs are a part of the plot record. They illustrate conditions of the plot better than record descriptions.

Camera prints or photographic monuments should be set, if a sequence of photographs are to be taken.

A record should be made of each picture when taken. The record should show - the photograph number, date, stop, and exposure used, light conditions, hour, position of camera, and direction of view.

RE-MEASUREMENTS:

Old records should be carefully reviewed before a plot is remeasured so that the technique and procedure will be understood.

Remeasurements should be made at the same season of the year that the original data was taken.

Corners and stations should be repaired or replaced; numbers, tagged or painted, renewed; and boundaries reblazed or painted if necessary.

New pictures should be taken if there is any visible change.

INTERVAL BETWEEN MEASUREMENTS:

The proper interval between remeasurements depends on the rate of change of the plot.

A five year interval is usually satisfactory if for a stand above the reproduction stage; but if the growth is rapid, the interval may be less.

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