FORESTRY 212

A STUDY of the UNDERPLANTED SPRUCE in the WOODLOT OF THE BARNES FARM

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C.C.Delavan
1932

A STUDY of the UNDERPLANTED SPRUCE in the WOODLOT OF THE BARNES FARM

The following study was undertaken in the attempt to determine the effect of a liberation cutting in the overstory of oak and hickory on underplanted Norway spruce.

Until 1908 the woodlot on the Barnes Farm near the village of Geddes, in the Town of Geddes, Washtenaw County, Mich., was the oak - hickory mixture common to the vicinity. The black oak (Q.velutina) and red oak (Q. rubra) predominated over the white oak (Q. alba) and hickory (H. ovata). The woodlot had been grazed and there were practically no young trees or reproduction in the stand. In the spring of 1908 that part of the woodlot south of the road was underplanted with Norway spruce (P.excelsa), eastern white pine (P. strobus), ponderosa pine (P. ponderosa), Scotch pine (P.sylvestris), and catalpa (C. speciosa). The stock used was two year old seedlings. They were planted in the openings with little attempt at regularity of spacing.

The underplanted stock had not become very conspicuous by 1914. No figures as to average height are available. At that time a liberation cutting was made in the north end of the underplanted area, the material removed being used for posts and fuel wood. A few stumps in the area south of where the liberation cutting was made indicate that the removal of a little timber has taken place there. It is believed, however, that these were dead or broken trees.

A fence was put up between the two areas. Grazing was almost, but not entirely absent on the area where the liberation cutting had been made but was permitted more or less intermittantly more or less intensively on that part of the area where there had been no systematic cutting.

It may be worth noting at this point that repeated planting of spruce in the open on lands in the vicinity for a number of years subsequent to 1908 failed to establish any successful plantation of this species. The conditions in the open were evidently too adverse to permit this species to become established. The few scattering trees which have survived and which have been permitted to remain have made good growth. They are, of course, open grown trees with limbs the full length of the tree.

There are certain features of the two areas which must be kept in mind in the interpretation and evaluation of the data later presented. The area of the liberation cutting has a nearly flat, level surface. There is a very slight slope to the south but it is so slight as to be scarcely perceptable to the naked eye. The area where there was no cutting has little level area. The slope here is from 0 to about 15% in a south and southeasterly direction. No distinguishable differences between the soils of the two areas could be found. There appears to be the same composition, texture and condition in the two areas. The ground cover was similar in both areas.

There now seems to be (1932) a very apparent difference in the growth made by the underplanted species on the area which was liberated and on the area which was not. The effect of the liberation cutting in causing this difference was considered apparent and some measure desired.

One plot was selected in each area. For convenience in referring to them the plot in the area of the liberation cutting will be referred to as Plot 1 and the other as Plot 2. Diagram I shows the relation of these plots to each other and to the area in general. They were selected with a view to minimizing the possible differences in site qualities as much as possible. It is felt that the trees on Plot 1 are perhaps a little below the average of the area which they are supposed to represent while those on Plot 2 may be a little above the average for their conditions. Yet if the plots had been chosen so that they would have represented average conditions they would have been so far apart that the site differentials might have been so great as to cause too great confusion with the effects of the liberation cutting.

The diameter and height of each tree in the plot was determined, as well as its location in the plot. Trees adjacent to the boundaries of the plot were platted if it appeared that they would have significant effect on the trees within the plot.

The recorded diameters of living trees are the average of two measurements taken breast high at right angles to each

other. Diameters were measured with calipers. The heights of the smaller trees were measured with a pole and heights of the larger trees were measured with a Forest Service hypsometer. Horizontal location of the trees in the plot was determined by measuring at right angles to parallel lines which divided the plot into narrow strips

It is believed that the measurements are accurate within the following limits:

Diameters - Less than 18" ± 0.1 inch

Over 18" +0.1 inch, -0.4 inch

Heights -

Less than 15 feet	±1 foot
15 feet to 24 feet	±2 feet
25 " " 35 "	±3 feet
Over 36 feet	±7 feet

Horizontal location - ±2 feet on either or both coordinates.

An analysis and summary of diagrams II and III shows the conditions on the two plots to be as follows as regards tree growth:

Plot 1:-

15 stumps of trees cut in the liberation cutting with a basal area of 10.368 square feet. This basal area was computed on the basis of diameter breast high.

27 trees of the original stand with a basal area of 34.166 Sq.ft. (99.2 sq.ft per acre.)

247 trees of Norway spruce with a basal area of 6.683 square feet, an average height of 16.1 feet and an average diameter, breast high, of 2.23 inches. (19.38 sq.ft. per acre.)

15 ponderosa pine with a basal area of 0.210 square feet, an average height of 11 feet and an average diameter of 1.5 inches.

8 catalpa with an average height of 17 feet and an average diameter of 1.5 inches.

101 pin cherry with a basal area of 1.627 feet, an average height of 18.2 feet and an average diameter of 1.47 inches. (Basal area of 4.76 sq.ft. per acre.)

Plot 2:-

7 stumps of trees cut sometime within the past 18 years with a computed basal area of 4.663 square feet.

30 trees of the original stand with a basal area of 35.392 square feet. (100.6 sq.ft. per acre.)

224 spruce with a basal area of 3.567 square feet, an average height of 11.3 feet and an average diameter of 1.70 inches. (10.34 square feet basal area per acre).

205 cherries with a basal area of 1.499 square feet, an average height of 12.3 feet and an average diameter of 0.94 inches. (4.35 sq. ft. per acre.)

There are no pine or catalpa on this plot.

Increment borings were made in ten trees within each plot and the average diameter growth for the past 18 years determined. This average diameter was subtracted from the diameter of each of the trees of the original stand. These remainders were taken as the diameters of the trees as they stood on the plots prior to the liberation cutting in 1914. The basal areas were then computed and to these figures were added the

basal areas of the trees cut.

Table 1 on the following page shows the radial growth, in inches, for the past 24 years by six year periods. The six year period was selected because it seemed a convenient period for an analysis of the 18 year data. It is believed that the ten trees selected in each plot were fairly representative and that the average of the growth of these trees will give a reasonable figure for the growth of the trees on the respective areas.

Table 2 shows the diameters and basal areas of the trees in the overstory as of 1914 and 1932. Table 3 shows the basal areas of the trees represented by the stumps on the two plots. The curve showing the relation of the stump diameter breast high is shown on Plate 1.

The average periodic growth in diameter for the past period of 18 years has been 1.8 inches in Plot 1 and 2.0 inches in Plot 2.

The liberation cut removed 10.368 square feet of basal area from a total of 37.054 square feet. This amounts to 28% of the basal area that was on the ground at the time. Trees with a basal area of 4.66 square feet have been removed from the plot on which no liberation cut was made. This amounted to 17.9% of the total basal area.

Plate 2 shows the average growth plotted for the four periods, three following the cut and the six year period pre-

TABLE 1

RADIAL GROWTH FOR THE FOUR SIX YEAR PERIODS, 1908 - 1931 inc.
Inches

Liberated Plot					Not Liberated				
Tree No.	Period 08-13	14-19	20-25	26-31	Tree No.	Period 08-13	14-19	20-25	26-31
1	0.46	0.36	0.30	0.31	11	0.56	0.47	0.38	0.42
2	.29	.29	.25	.21	12	.44	.40	.40	.42
3	.27	.30	.30	.24	13	.30	.32	.34	.36
4	.15	.12	.15	.16	14	.42	.42	.57	.57
5	.28	.38	.36	.38	15	.34	.26.	.28	.36
6	.28	.31	.33	.32	16	.25	.19	.24	.22
7	.16	.20	.20	.17	17	.25	.28	.28	.26
8	.40	.48	.50	150	18	.30	.26	.31	.29
9	.30	.31	.36	.34	19	.36	.38	.34	.28
10	.26	.51	.40	.36	20	.28	.24	.29	.24
Sum	2.85	3.06	3.15	2.99		3.48	2.22	3.43	3.32
Ave.	.285	.306	.315	.299		.348	.222	.343	.332

TABLE 2

BASAL AREAS OF OVERSTORY AS OF 1931 and 1914

Plot 1					Plot 2				
Species	1931 D.B.H.	B.A.	1914 D.B.H.	B.A.	Species	1931 D.B.H.	B.A.	1914 D.B.H.	B.A.
W.O.	7.6	0.315	5.8	.0.184	W.O.	8.5	0.394	6.5	0.230
B.O.	17.5	1.670	15.7	1.344	B.O.	17.6	1.689	15.6	1.327
W.O.	10.2	.568	8.4	.385	B.O.	14.6	1.163	12.6	.866
B.O.	22.0	2.640	20.2	2.226	R.O.	14.6	1.163	12.6	1.163
B.O.	18.8	1.928	17.0	1.567	W.O.	14.1	1.084	12.1	.812
H	10.1	.556	8.3	.376	R.O.	15.0	1.227	13.0	.922
B.O.	15.0	1.227	13.2	.950	W.O.	12.6	.866	10.6	.613
H	9.5	.492	7.7	.323	B.O.	16.1	1.414	14.1	1.084
W.O.	14.6	1.163	12.8	.894	B.O.	14.5	1.147	12.5	.852
B.O.	14.7	1.179	12.9	.908	R.O.	16.0	1.396	14.0	1.069
B.O.	17.0	1.576	15.2	1.260	B.O.	13.5	.994	11.5	.721
B.O.	16.8	1.539	15.0	1.227	B.O.	18.5	1.867	16.5	1.485
B.O.	18.1	1.787	16.3	1.449	W.O.	7.5	.307	5.5	.165
B.O.	17.4	1.651	15.6	1.327	B.O.	11.3	.697	9.3	.472
H	7.5	.307	5.7	.177	R.O.	17.2	1.614	15.2	1.260
W.O.	8.6	.403	6.8	.252	B.O.	19.7	2.117	17.7	1.709
S.M.	13.5	.995	11.7	.747	W.O.	9.6	.503	7.6	.315
B.O.	15.4	1.294	13.6	1.009	B.O.	18.7	1.907	16.7	1.521
B.O.	19.0	1.969	17.2	1.614	R.O.	20.5	2.292	18.5	1.867
B.O.	12.4	..839	10.6	.613	B.O.	13.8	1.039	11.8	.760
B.O.	15.4	1.294	13.6	1.009	R.O.	12.0	.785	10.0	.545
R.O.	12.5	.852	10.7	.625	R.O.	11.9	.772	9.9	.535
B.O.	12.1	.799	10.3	.579	B.O.	13.4	.979	11.7	.709
B.O.	15.0	1.227	13.2	.950	R.O.	21.7	2.568	19.7	2.117
B.O.	18.1	1.787	16.3	1.449	R.O.	13.5	.994	11.5	.721
B.O.	16.0	1.396	14.2	1.100	R.O.	15.8	1.362	13.8	1.039
B.O.	14.2	1.100	12.4	.839	R.O.	12.7	.880	10.7	.625
B.O.	17.2	1.614	15.4	1.294	W.O.	6.8	.252	4.8	.126
		34.166		26.686	B.O.	16.8	1.539	14.8	1.195
							35.021		26.582

PLATE 1

Relation of Diameters at 1 and 4½ ft.

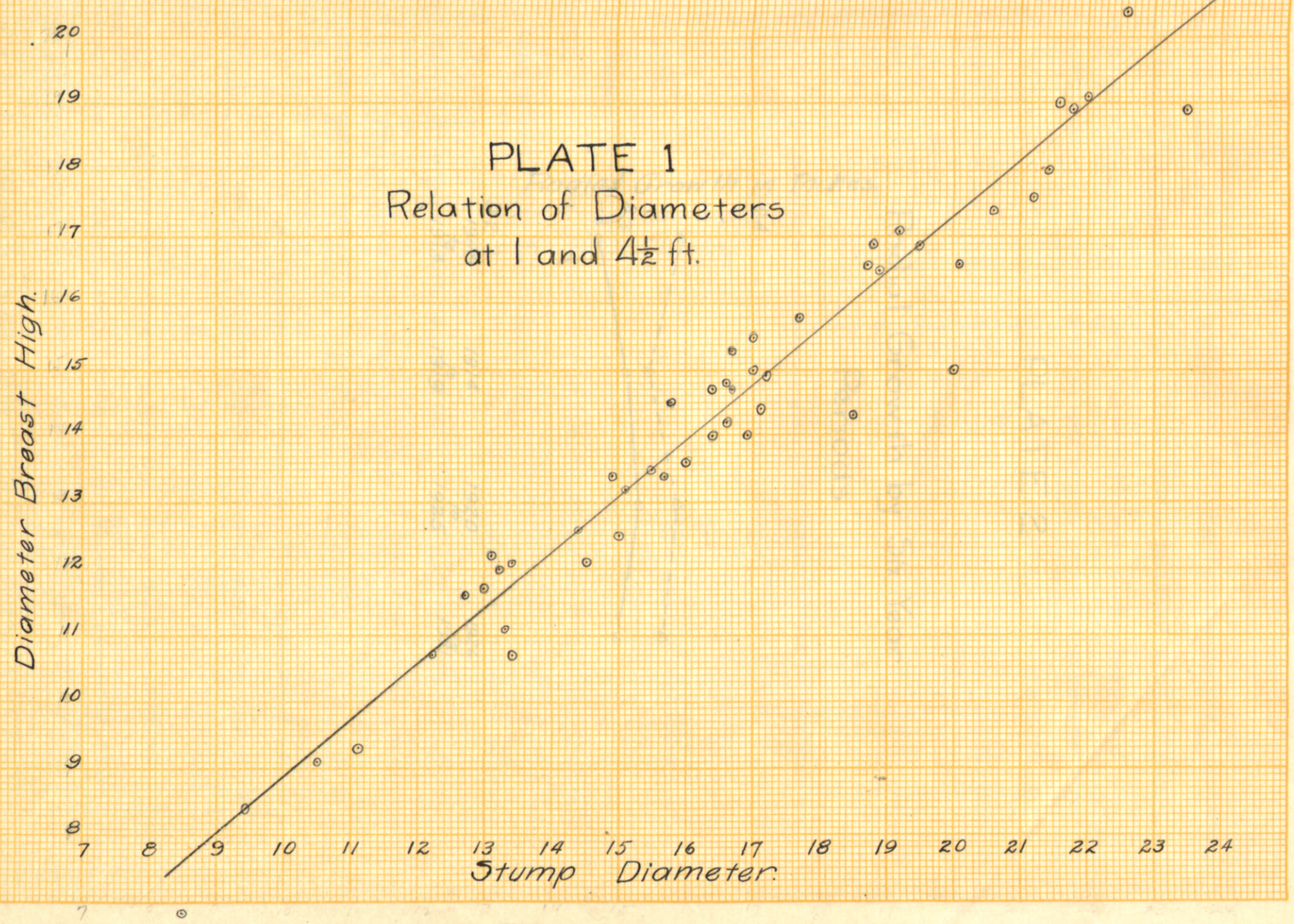
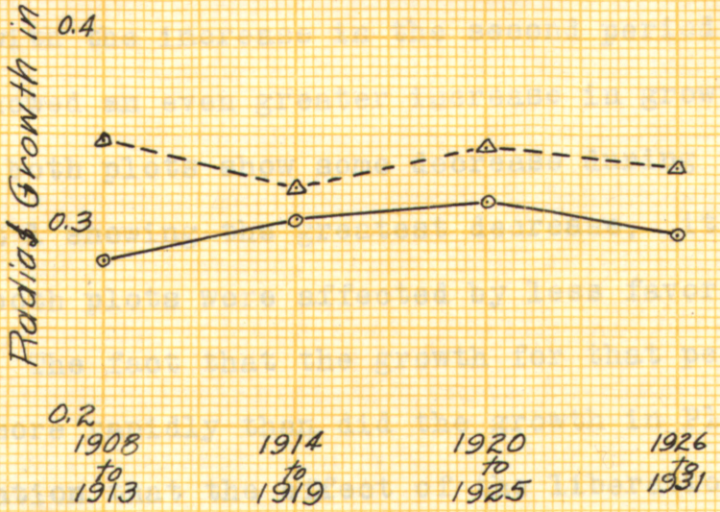


PLATE 2

Radial Growth by Six Year Periods



ceeding this cut. Growth on Plot 1 showed some increase for the the two periods following the cut but a decline in the rate of growth for the last period. In Plot 2 there was quite a sharp decrease in growth in the first period following the cut, an increase over that in the second period, and a less abrupt decrease in growth during the third period. In view of the decrease during the first period in the latter plot it is very reasonable to attribute part of the increased growth in Plot 1 during the first period to the liberation cut.. It is not so apparent that the liberation cut had so much to do with the increase in the second period since growth in Plot 2 showed an even greater increase in growth than did Plot 1. As both plots show some decrease during the third period, Plot 1 showing the greatest decrease, it is probable that both plots were affected by less favorable growing conditions. The fact that the growth for that period in Plot 1 declined more rapidly than did the growth in Plot 2 might be an indication that the effect of the liberation cut was wearing off. The basal area of Plot 1 has increased to within three feet of the area before the cut.

Growth of the overwood on the two plots has been as follows: On Plot 1 the increase in basal area has amounted to 7.480 square feet, or 28% increase on the initial basal area of 26.686. On Plot 2 there has been an increase of 8.493 square feet or 32% increase on an initial basal area of 26.528. The coincidence that the basal area of the two plots, as computed as of 1914, differs by only 0.158 square

feet is significant and should be noted at this point as other deductions will be related to it later. It should also be noted that the growth of the overwood is more rapid in all periods on Plot 2 than on Plot 1.

If we may assume that about the same number of trees were planted on each of the two plots, and such assumption seems very reasonable, it is evident that the survival on Plot 1 was much better as we how have 260 survivors there against a total of 224 on Plot 2. Too much significance should not be place in this figure however, because the greater amount of grazing permitted on Plot 2 may have been the cause of the death of some of the plants by trampling. This increased grazing may also account forthe smaller size and greater number of cherry trees on Plot 2. Because of the obvious possible effects that grazing may have had on this species no particular significance is placed in the data referring to it. Becuase ther are no pine or catalpa on Plot 2 these species also lose value as a basis of comparison of the two plots.

We find, however, that the 247 spruce on Plot 1 have a basal area of 6.683 square feet, an average height of 16.1 feet and an average diameter of 2.23 inches while on Plot 2 there are 224 spruce with a basal area of 3.567 square feet, an average diameter of 1.7 inches and an average height of 11.3 feet. The basal area is therefore hearly twice as great on Plot 1 as on Plot 2; the trees average nearly five

feet taller; and nearly half an inch larger in diameter. Volume being a function of both height and diameter there is an indicated relation in volume between Plot 1 and 2 of 2.93 to 1, or nearly three times as much volume of spruce on Plot 1 as on Plot 2. If the pine and catalpa that are on the area had been spruce these relations would show a still greater difference in favor of Plot 1.

Another condition which was noted, and which should be considered in the interpretation of the foregoing data, was the condition of some of the spruce. On Plot 1 13 spruce show partial defoliation or other evidence of poor condition. Twelve of these show dead leaders. The total length of the dead portions of these leaders amounts to 28 feet in this plot.

In Plot 2 21 spruce trees show similar evidences of poor condition with a total length of dead portions of 46 feet. Expressed in percentages of the total number of spruce trees on the plots the affected trees amount to 9.3% on Plot 2 and 5.3% on Plot 1.

The cause of this poor condition is generally attributed to the extremely dry summers of 1931. A similar condition was noted in the same species on the Saginaw Forest and every evidence pointed to this cause. Certainly there was no evidence of insect or fungus attack on trunk, twigs, needles, or roots of the affected trees examined. The root system of the spruce in this plantation shows the usual characteristics

of this species and is comparatively shallow. Examination of thees from this plantation removed by nurserymen for ornamental planting show the great body of the roots to be in the top 12 - 15 inches of soil. Evidences of the removal of oak sthmps in the vicinity show these trees to be much more deeply rooted. There is ample support for the statement that the roots of the two species generally occupied separate soil strata. Certainly the deciduous oak is much better able to adjust its transpiration area to deficiencies in soil moisture without serious permament damage than is the spruce. (1)

Briefly summarized, therefore, we have the two plots starting 1914 with the trees in the overstory having very nearly the same basal area. The spruce on Plot 1 have survived better, grown more rapidly in both height and diameter, and have suffered less from the dry weather than have the spruce in Plot 2. On the other hand the oak has made much better growth on Plot 2. The oak had also made better growth on Plot 2 during the six years prior to 1914.

Basal area is considered as good an indication of stocking as can be secured (2) so that we are fairly safe in the assumption that the two plots were about equal in this respect after the cutting was made. It is also reasonable to suppose that the composite competition offered by two stands will equally well stocked and with similar composition will be about equal if other factors are the same. It would seem therefore, that the drain by the oak on the two plots would be about

equal. We might expect to find the height growth of the spruce stimulated for the period just after the cutting and then progressively decrease as the surrounding oak extended its roots and crowns into the area vacated by the cutting. We find, however, that the height growth has been much better on Plot 1 during the past 6 year period than it has been on Plot 2 although it is hardly probable that the effect of the liberation cut would continue for this length of time. Certainly the growth figures of the oak itself do not support any such assumption.

On the other hand what are the differences in site factors that might have caused the spruce on Plot 2 to grow less rapidly than those on Plot 1? The sli ght slope to the south and east would undoubtedly have some effect on the temperature of the soil and hence on the soil moisture. It is generally regognized that a south slope is warmer because of the greater insolation. The greatest effect of this increase in temperature with its attendant decrease in soil moisture would naturally be felt in the upper layers of the soil where the bulk of the spruce roots lie more than in the deeper layers occupied by the oak. There is little doubt that Plot 2 is also more exposed to the effect of wind than Plot 1 and hence suffers from increased transpiration and evaporation on that account.

With these data it seems very inconclusive that the greater growth of the spruce on Plot 1 was due to any great extent to the liberation cutting. It seems even more probable that a difference in the physiographic site factors has been

responsible for a greater dessication of the upper layers of the soilin which the spruce roots are located, in Plot 2 than in Plot 1. This would account for the greater mortality among the spruce, the poorer growth, and the greater number of trees in poor condition at the present time. (3) (4)

It is evident, from an inspection of the stand in the field and from examination of the diagrams that there appears to be some relation between the location of the oak and the growth of the spruce. While this appeared evident it was not so easy to demonstrate it by tabular or graphic methods. The following method was devised and seems fairly satisfactory.

It was arbitrarily assumed that each of the trees of the original stand would exert an influence within a fifteen foot radius. A circle with this radius was drawn around each tree of the original stand. Columns were prepared with headings which indicated the number of oak trees than caused influence as 0, 1,2 and 3. The diameter and height of each spruce was then tabulated in its proper column depending on whether it was included in 0, 1,2 or 3 circles. The summation and averaging of these tabulations gave the following figures.

Number of oak influencing.	Plot 1			Plot 2		
	No. Spr.	DBH	Hgt	No.	DBH	Hgt.
0	50	2.46	20.4	48	1.65	12.0
1	111	2.10	15.9	104	1.53	11.3
2	74	1.96	14.5	57	1.38	10.7
3	12	1.70	13.7	15	1.46	10.6

With only one exception the size of the tree decreases as the influence of the overstory increases. In the exception noted the number of trees on which the figure is based is too

small to give a reliable average. However arbitrary it may be to assign to each tree of the original stand an influence with a radius of 15 feet it is evident that the spruce generally has done better the more free it has been of this influence.

Summary.

The liberation cutting removed 10.368 sq.ft. of basal area on the plot - or 31.07 sq.ft. per acre.

Computed basal areas for 1914 showed the overstory to be nearly equal on the two plots at that time.

Oak has grown better on Plot 2, both before and since the time of the cut.

Spruce has survived and grown better on Plot 1; the trees averaging 5 feet taller, about ½ inch larger in diameter, nearly twice as much basal area and nearly three times the volume on the plot.

The liberation cut seems to have had less effect on the survival and growth than other site factors.

In both plots the less the spruce is under the influence of the oak the better it has grown. In similar situations in this respect however spruce on Plot 1 is larger than on Plot 2.

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PLOT I

Representing Area of Liberation Cut

Barnes Woodlot.

Plot is 100'x150'

N

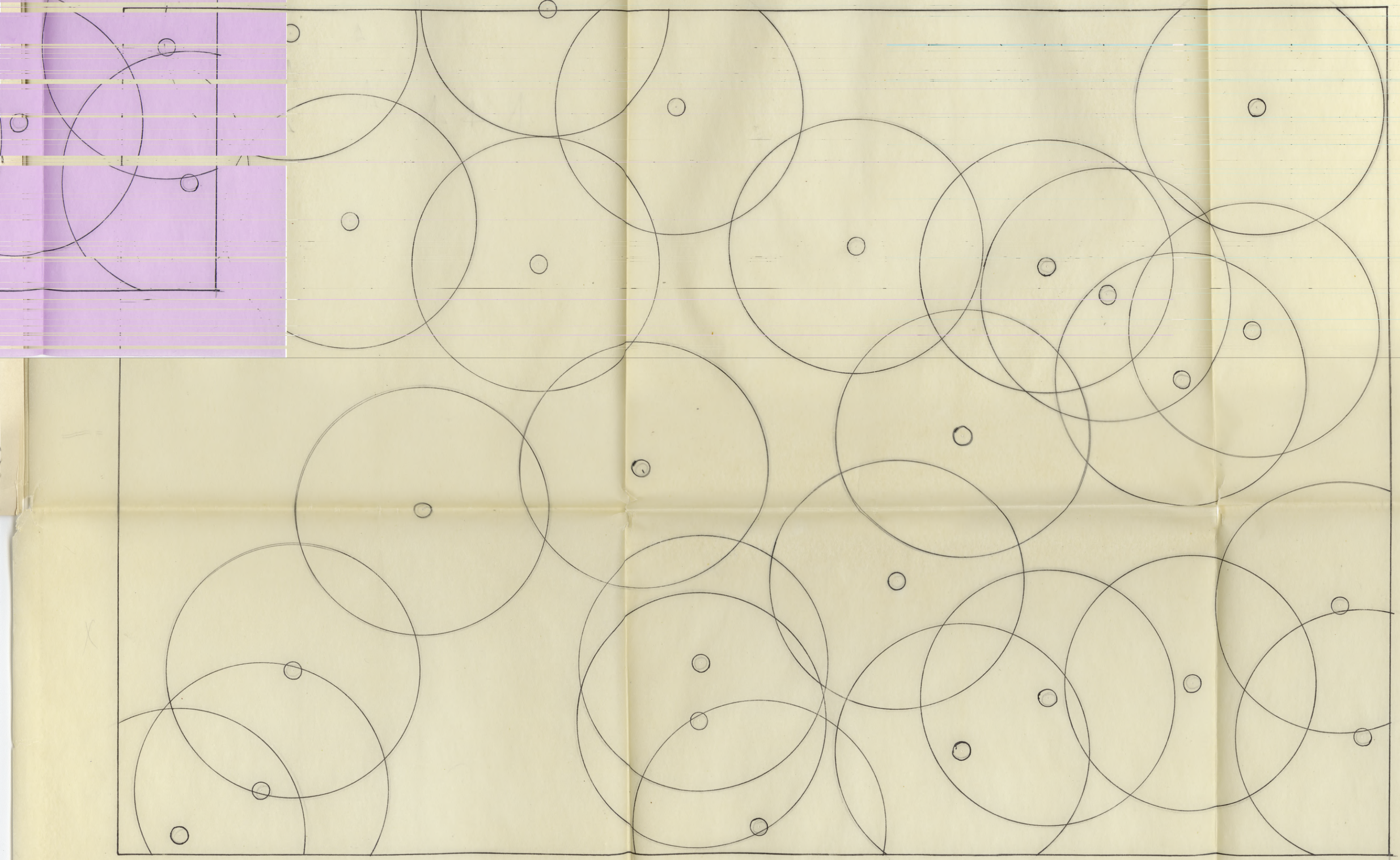
Legend

- W.O. 15.2-70 — Showing species, DBH, and Height.
- Spruce - Diameter and Height
- Cherry - " " "
- Ponderosa Pine " " "
- Stump
- 3 2.1-18 — Tree in poor condition - Length of dead leader shown by - figure.

PLOT 1

Diagram

Showing Influence of Overstory



PLOT 2

Representing Area of No Liberation Cut.

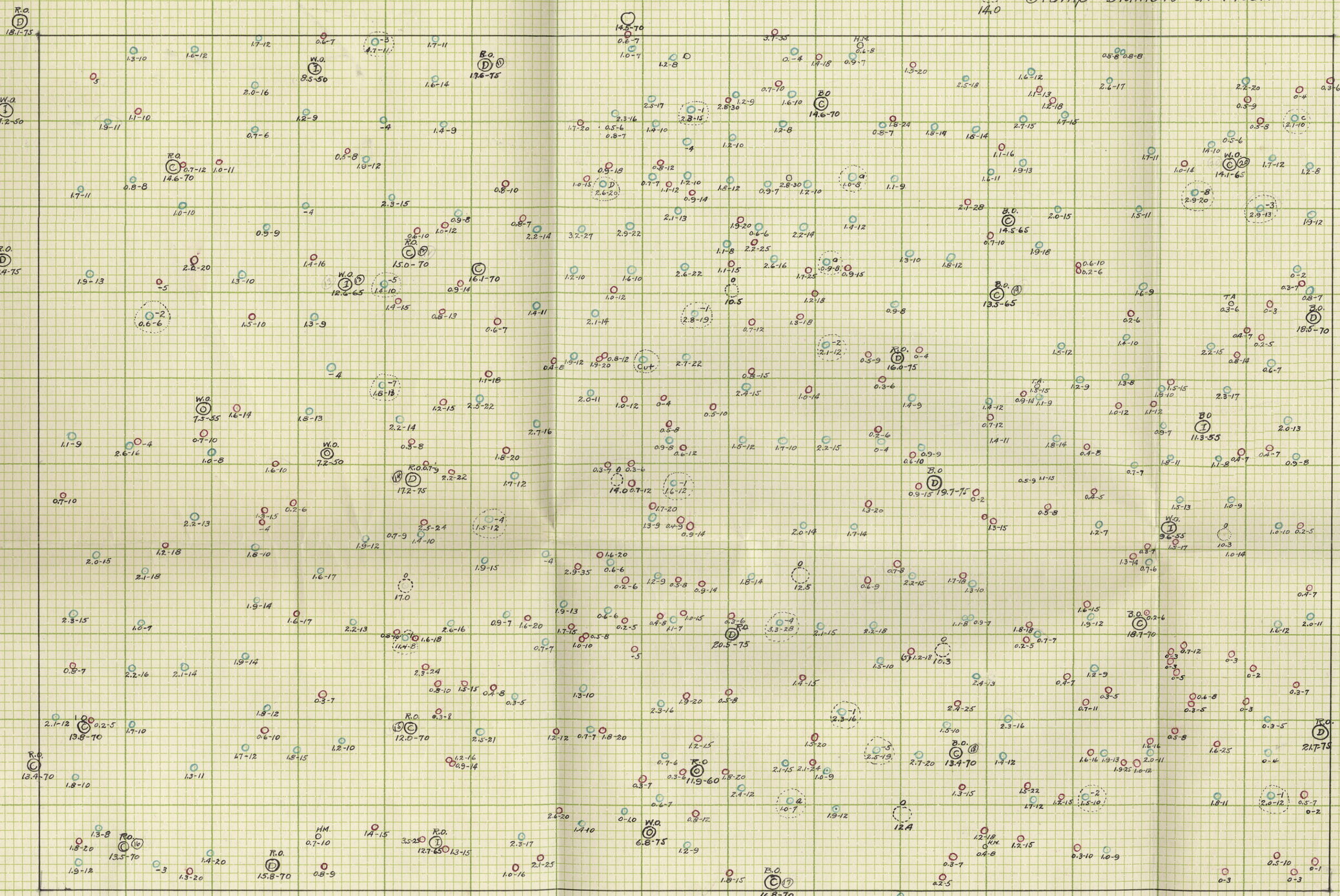
Barnes Woodlot.

Plot is 100' x 150'

N

Legend

- B.O. D 13.6-75 — Showing Species, D.B.H. and Height.
- Spruce - diameter and height.
- Cherry - " " "
- -3 1.8-15 — Tree in poor condition, minus figure indicates length of dead leader.
- 14.0 — Stump - Diameter at 1 foot.



June 1932.

PLOT 2

Diagram

Showing Influence of Overstory