A STUDY OF THE PERIODICITY OF SEED YEARS AND DIRECTION OF SEED DISTRIBUTION OF THE WHITE PINE IN THE VICINITY OF ITHACA,N.Y.

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by

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INTRODUCTION.

The question of the periodicity of seed years has long been a subject of discussion and some study among foresters.In fact this subject dates back to the very beginning of the science.The primary question to be solved in the culture of trees in the forest,or anywhere else for that matter,is the problem of reproduction.When natural reproduction is to be used in the regeneration of the forest it is of the utmost importance to know when the seed will be distributed,in order that the trees may be removed at the proper time.If seed trees are to be left,we must know how far and in what direction the seed will be scattered.When artificial reproduction is to be used it is a great advantage to know when and where seed is to be produced in large quantities,so that the expense of collection may be kept at the minimum.

Up to the present time the controlling factors influencing the periodicity of seed years have not been understood,and about all we know of the subject is that white pines do seed periodically,that a seed year may be expected every three or four years,that a seed year is a local phenomenon and not widespread over the white pine region,and that occasionally we may may have an unusually abundant seed year. These are the facts,but when we are asked to explain them,we find our present knowledge insufficient to more than hazard a guess.There are so many factors of which we know so little that before any definite conclusions can be reached we must have detailed observations on each one of these.These observations cannot be made by any one person or in any one place,but must be made at points well distributed over the

range of the tree selected for study, in this case the white pine, and must cover a long period of years. After this work has been done and only then can we be sure of our ground.

The principal factors which may influence the production of seed may be outlined as follows:-

I. Influences within the tree itself.

1. Storage of surplus food to be used in seed production.
2. Years staminate and pistillate flowers are produced
3. Photosynthesis and other physiological actions of the tree.

II. External influences.

1. Meteorological conditions.
   a. Maximum and minimum temperatures.
   b. Latest and earliest killing frosts.
   c. Prevailing winds.
   d. Effect of sudden changes.
   e. Precipitation.
2. Soil.
   a. Character.
   b. Drainage.
   c. Available water.
3. Exposure.
4. Effect of light and shade.

It has been beyond the scope of this problem to take up all these points but they have suggested themselves during its pursuance. This work has been confined, so far as seed production is concerned, to a survey of the woodlots on the Cornell University Farm, recording seed crop conditions during the fall of 1914, and the collection of such meteorological data as is available.

The study of seed distribution is more simple, since only a

few factors are involved. Wind is of course the most important of these in the consideration of winged seeds like those of the white pine. This part of the study has been taken up in connection with the reproduction study during the summer of 1915. The plan followed has been to make rough maps indicating the relative positions of reproduction and seed trees and to record other data having a bearing on the subject, as illustrated on the sample record under methods of collecting data.

In addition to this enough trees have been cut in each plot, and the annual rings counted, to ascertain the various ages of reproduction, to determine the seed years for the last forty years.*

The object of this study has been to collect such data as will be useful, combined with future observations, in the solution of these problems rather than to attempt a solution at the present time.

METHODS USED IN COLLECTING DATA.

In collecting data in this work the following methods have been used:-

In the study of the woodlots in regard to the seed crop of the fall of 1914 each woodlot was taken separately and a card was kept for each species. The trees of each species were divided into the usual crown classes; Dominant, Codominant, Intermediate, and Suppressed. The records were kept on 4X6 cards as illustrated in the following specimen.

*If a dry year should follow the distribution of seed it is probable that many of the seeds would lie over and not germinate the summer following their distribution. During seasons of normal rainfall, however, the majority of the seeds should germinate the first summer, judging from germination as found in the seed beds in this locality.

Date. 10/10/1914 Species:- Pinus strobus.

Age class – 80 to 100 Veterinary Woods.

Seed Crop.

Dominant					
Codominant.					
Intermediate.					
Suppressed					

Incidentally each woodlot has been roughly mapped. Since the terms abundant, fair, poor are rather indefinite, and often used comparatively it seems advisable to define exactly what is meant by these terms as used in this study. If the cones averaged eight or more to the bunch and each of the principal upper branches of the tree bore a bunch the crop was considered abundant. If only one half the upper branches bore cones the crop was considered fair. Any smaller crop was considered poor.

An attempt was made to count every white pine and a fair proportion of other species in each woodlot.

The reproduction study was made during the summer of 1915, and the following form was used in keeping field notes.

Date 6/8/1915. Location:- Smith woods. Plot #1

Direction of prevailing wind as indicated by.		Ages of Reproduction found.	Height of Reproduction	Density	Max. dist. from seed trees.
Trees in Open	Reproduction				

Proportion of Ages Found.	

The definitions of dense,medium,and open reproduction will be necessary to explain these terms as used in this work.If the trees are 6X6 feet apart or closer,they are termed dense.If they are spaced 10X10 to 6X6 feet they are termed medium.Amy wider spacing is termed open.

Each woodlot having in or about it natural reproduction has been taken up separately and in addition other plots in the vicinity of Ithaca have been included.Where possible the various stands of young stock have been photographed and will be used to illustrate this paper.

SEED YEAR OF 1914 IN THE CORNELL UNIVERSITY WOODLOTS.

A seed year may be defined as a year when the majority of dominant trees bear seed to a greater or less extent.The following tables show the percent of white pines which bore seed ripening during the fall of 1914.Since this specie s has received special attention in this study,the tabulations for it will be made separately.The other species will all be included in one table.

Percent of White Pines Bearing Seed During 1914.

Age Class 90-100 — *Species:- Pinus strobus.*

	Veterinary Woods				*Orchard Woods.*			
	Abundant	*Fair*	*Poor*	*None*	*Abundant*	*Fair*	*Poor*	*None.*
Dominant.	6.3 %	34.2 %	21.3 %	38.2 %	58.3 %	33.3 %	2.7 %	5.7 %
Codominant			14.3 %	85.7 %				100 %
Intermediate				100 %				100 %
Suppressed.				100 %				100 %
	Meade Woods.				*Poultry Woods.*			
	Abundant	*Fair*	*Poor*	*None*	*Abundant*	*Fair*	*Poor*	*None.*
Dominant	42.1 %	32.6 %	11.5 %	13.8 %			3.2 %	96.8 %
Codominant				100 %				100 %
Intermediate				100 %				100 %
Suppressed				100 %				100 %

Age Class:- 80-100. Species:- Pinus strobus.

	Cyclone Woods				Smith Woods.		
	Abundant	Fair	Poor	None	Abundant	Fair	Poor	None.
Dominant	No White Pine.						25 %	75%
Codominant								100%
Intermediate								100%
Suppressed								100%

	Mitchell Woods				Slim Jim Woods.			
	Abundant	Fair	Poor	None	Abundant	Fair	Poor	None.
Dominant			28.1%	71.9%			6.3 %	93.7%
Codominant				100%				100%
Intermediate				100%				100%
Suppressed.				100%				100%

	Open				Circle.			
	Abundant	Fair	Poor	None	Abundant	Fair	Poor	None.
Dominant	40.5 %	8.1%	35.1%	16.3%	9.33 %	17.33 %	24%	49.34 %
Codominant								
Intermediate.								
Suppressed.								

The table for the Circle is for a planting of young trees which vary in age from 15 to 20 years and are growing in open formation. These trees have born some cones each year for the last few years. In this table those trees bearing 25 or more cones were considered as having an abundant crop, those having from 10 to 25 as having a good crop, and those having from 1 to 10 as having a poor crop.

From the above tables it is evident that in most of the woodlots containing white pine to any great extent a majority of the dominant trees bore seed. In the open a much larger percent bore an abundant crop.. Nevertheless when we consider that in the Poultry Woods, where the white pines are numerous, there was practically no seed crop and that in a number of other woods, outside the Cornell University Farm the white pines produced no seed, we must consider the seed year of 1914 as being comparatively light. The fact that such a large proportion of trees in the open bore seed may explain the appearance of a heavy seed year to the causual observer, and emphasizes the necessity of making detailed observations in order to be sure of the exact conditions existing.

One point brought out in this survey was that the same

Weather Conditions & Seed Production During the Past 40 Years.

Year	Seed Crop	Killing Frosts		Ann. Temp.		Temperatures						Ann. Precip.	Precipitation.		
						June		July		Aug.					
		Latest	Earliest	Max.	Min.	Max	Min	Max	Min	Max	Min		June	July	Aug.
1875	None											28.98	3.83	1.72	3.94
1876	Fair. F											33.63	5.11	4.96	1.77
1877	None.											23.48	3.49	1.87	1.25
1878	None											38.65	4.76	3.80	3.91
1879	Good G		Sept. 25	93	- 8	90	38	93	50	88	49	20.27	2.80	4.05	0.73
1880	None	May 15	Oct. 14	94	-12	93	40	94	48	91	43	29.01	1.86	4.52	3.15
1881	"	" 1	" 11	96	-10	85	40	95	53	96	48	32.91	3.90	2.92	0.39
1882	"	" 3	" 21	94	-15	94	42	92	50	93	44	30.12	2.64	2.33	2.85
1883	"	" 14	" 5	91	-8	89	42	91	44	90	42	35.44	7.54	4.31	2.81
1884	Abundant	" 29	" 10	94	-20	94	44	91	48	91	39	34.17	1.35	4.87	3.75
1885	None	" 12	" 8	96	-14	88	41	96	46	88	40	35.10	3.69	2.84	8.14
1886	"	Apr. 9.	" 16	96	-11	90	41	96	46	92	47	32.93	2.28	4.55	1.69
1887	"	" 25	" 15	95	-12	92	48	95	56	90	42	30.73	3.47	3.97	3.04
1888	Fair.	May 3	" 15	96	-15	96	40	93	48	92	46	30.97	2.37	2.33.	3.36
1889	None	Apr. 23	" 16	92	-12	82	42	92	50	86	48	42.04	6.74	6.73	3.32
1890	"	May 2	Sept. 25.	96	-3	88	48	96	44	92	46	46.39.	4.94	1.24	4.92
1891	"	" 6	Oct. 12	92	-2	92	37	90	47	92	47	38.05	4.56	4.25	3.24
1892	Fair.	Apr. 26	" 2	95	-6	93	47	95	46	93	52	40.49	5.20	4.93	6.91
1893	None	" 26	" 16	93	-12	93	46	92	45	91	43	37.58	2.20	5.13	3.86
1894	"	May 29	Sept. 26.	95	-14	90	36	95	48	89	42	40.15	3.40	3.17	0.59
1895	Fair	" 22	" 15	95	-9	95	44	90	43	89	41	28.66	3.37	1.96	4.12
1896	None	Apr. 9.	Oct. 10	94	-18	86	39	90	49	94	41	36.17	4.36	3.69	2.43.
1897	"	Apr. 27	Oct. 8	94	-6	85	39	94	56	83	46	33.67	3.54	3.35	2.74
1898	Good.	" 22	" 17	96	-4	90	40	96	40	89	42	39.55	3.01	4.17	4.42
1899	None	" 17	" 3	98	-16	95	38	96	46	98	43	27.55	1.99.	3.46.	2.31
1900	"	May 7	" 20	96	-2	91	44	96	46	95	46	32.77	1.98	2.41	2.93
1901	"	Apr. 12	" 28	95	-8	95	42	95	52	85	50	35.17	3.06	3.60	3.85
1902	Abundant	May 10	" 10	88	-2	85	39	88	52	88	45	35.73.	5.39	6.68	3.13
1903	None	" 2	" 25	92	-5	85	43	92	42	86	45	35.46	5.67	2.64	7.15
1904	"	" 12	" 7	91	-20	89	44	91	48	86	43	30.04	1.77	3.79	2.20
1905	"	" 2	" 26	90	-6	88	43	90	48	86	45	38.04	6.81	4.97	2.83.
1906	Good.	" 21	" 1	92	-11	87	37	88	48	92	46	33.14	7.06	1.94	2.53.
1907	None	" 12	" 21	93	-10	93	41	89	43	93	42	33.47	5.15	1.95	1.64
1908	"	" 5	" 10	96	-13	92	40	95	47	96	43	30.14	1.26	4.75	3.48
1909	Fair	Apr. 25	" 13	95	-8	90	45	90	43	95	42	27.20	3.97	1.62	1.63
1910	None	May 6	" 13	94	-6	91	38	94	49	89	40	31.65	1.14	1.62	2.39
1911	"	" 5	Sept. 14	102	1	94	44	102	50	94	45	31.91	3.59	2.53.	4.15
1912	"	Apr. 28	Oct. 16	96	-16	88	36	96	42	86	41	32.95	1.37	2.64	3.54
1913	"	June 9	Sept. 15	96	-1	94	32	96	48	96	46	49.48	2.00	1.59	1.92
1914	Fair	May 1	Oct. 25.	96	-15	90	39	91	48	96	44	32.33	4.75	1.89.	
1914.	None	" 27		90		88	41	88	49	88	42				

influences controlling the seeding of the white pine do not necessarily control the seeding of the other trees. There seems to be little relation in the seeding of the different species. The following table includes the other species beside the white pine which have been included in this survey.

1914 Seed Crop on Dominant Trees.

	Abundant	Fair	Poor	None.
Hicoria ovata		12%	16%	72%
" glabra.		20%		80%
Quercus alba.		13.33%	23.33%	63.34%
" rubra.	57.3%	30%	12.22%	1.48%
" velutina.		25%	50%	25%
Betula lenta.	45%	25%	28%	2%
Fagus americana.	67%	24%	18%	1%
Tilia americana.		10%	30%	60%
Acer saccharum.	57%	3%	3%	29%
Fraxinus americana.			5%	90%
Castanea dentata.	70%	12%	4%	14%
Carpinus caroliniana	80%	15%		5%
Ostrya virginiana.	50%	25%		25%
Tsuga canadensis.	76%	5%	5%	14%.

SEED YEARS OF THE WHITE PINE AS INDICATED BY NATURAL REPRODUCTION

The fall of 1914, as has been shown, was a fair seed year for the white pine. By cutting trees and counting the annual rings we find a remarkable uniformity of the various ages of reproduction in this vicinity. We find that in certain years the reproduction was heavy, in other years was lighter, and in still others there was no reproduction whatsoever. By adding one year to the age of these trees, the year in which the seed for each crop was produced has been determined. These observations have covered the country about Ithaca quite thoroughly and the results have been ~~quite~~ exceedingly uniform. It is possible that every seed year is not represented by reproduction as the conditions following the seeding may have been so adverse as to make the establishment of seedlings impossible.

It is certain, however, that during each year indicated as a seed year by the reproduction seed must have been distributed. Also the proportionate abundance of seed during these years is indicated is probably fairly well indicated by the abundance of seedlings for the respective years.

The following table shows the seed years of the white pine for the past forty years as indicated by the reproduction, in connection with the meteorological conditions existing during that period. From this table it is evident that the late and early frosts have apparently no influence on the seeding, for in 1913, when the flowers and young cones for the 1914 crop was produced, we had the latest and almost the earliest frost on record, but still a crop was produced. And so we may consider frost as a negligible factor so far as seed production ~~is~~ is concerned.

Next let us look at the annual temperatures. So far as can be seen from the figures at hand there appears to be no particular relation to the seed years in these temperatures. Neither do the temperatures for June, July, and August throw any light on the subject when considered alone.

The precipitation records, however, show some relation to the seed years and may, combined with the summer temperatures, give a hint as to ~~of~~ the answer to the question of periodicity of seed years. It is a well known fact that a tree may be forced to produce fruit by partial girdling. The explanation ordinarily given is that it is a provision of nature to provide against the extermination of the species, which is really no explanation at all. What happens when a tree is girdled? Nothing more or less than the cutting off of a part of the water supply from the ground. The same effect may easily result from drouth, and perhaps this may have something to do with the production of seed. Following out this theory we should expect after a year or two of drouth, or after years of moderate rainfall accompanied by excessive heat, which would produce the effect of drouth, that the white pines would flower, and bear seed the following year. Therefore the third and to a less extent the fourth year before the seed

year would be the years which would influence the bearing of seed.

During the year 1876 the earliest seed year indicated in this study occurred. Unfortunately we have no weather records previous to 1875. The next seed year was in 1879, when apparently a very good crop was produced. The year immediately preceding was wet, but in 1877 the rainfall was below the normal, especially in the latter part of the summer. So we have a drouth one year, flowers and the setting of fruit the year following, and the next year seed being produced?

The next seed year was in 1884. This was immediately preseded by a normal year. In 1882, however, the precipitation during the summer months was very low, and the average for the year was below the normal. This comparatively low precipitation was accompanied by high temperatures throughout the summer months, thus producing drouth conditions by an increase of the rate of evaporation and transpiration.

The next seed year was in 1888 and practically the same conditions preceded it as existed in the years preceding the previous seed year. The next seed year was in 1892 when a fair crop was produced. In this case our theory falls down, as the two years preceding were wet and but a fairly high temperature was maintained through out the summer months. The next year the precipitation was reduced and the summer was hot. This condition was followed by a seed year in 1895. 1895 was dry and the normal rainfall of the following summer was probably not sufficient to restore the soil to its normal condition. In 1897 the trees bloomed and set fruit and in 1898 a good crop was produced.

The next seed year was in 1902 when an abundant crop was produced. The years 1899 and 1900 were both dry and the drouth was accompanied by very hot weather. In 1906 there was a good seed year and 1904 was below the normal in precipitation. In 1909 there was a fair seed year

Preceeded by years of normal precipitation and with no excessive summer heat.The seed year was not very heavy and probably not very general as only a few seedlings of this age were found.If this year was not a general seed year,we should expect a seed year in 1911 since 1909 was very dry.No such seed year is indicated by the reproduction,the next year comming in 1914.Since 1912 was somewhat below the normal and was preceeded by a number of dry years,this seed year fits in with our theory exactly. The summer of 1915 has been very wet and rather cool,and following out our theory we should expect no seed year until 1918,and unless next summer is dry,not until 1919 or 1920.

There is not enough data at hand to warrant the unconditional endorsement of this theory,but there certainly seems to be some relation between precipitation,or rather available soil water,and the production of seed,and the periodicity of seed years.

In the Centralblatt fur das gesamte Forstwesen,for June,1906. there appeared a short article under "Notizen"entitled Die Ursachen der Blutenbildung.A rather free translation of this article appeared in the Forestry Quarterly,vol.4,page 205 and was as follows:-

"The celebrated plant physiologist,J.Sachs,maintained that flowering was dependent upon the presence of certain materials,produced at certain periods and acting as stimuli.In the Naturwissenschaftliche Wochenschrift (1905,p 573) the primary cause is sought in certain weather conditions which produce these materials and act upon them.That light is an essential factor in forming flower materials may be proved by placing plants in a dark room,when no flowers will be produced;similarly, shrubs shaded on one side and exposed on the other to full sunlight flower mainly on the latter side.Flower materials may,however,be deposited as reserve material in bulbs,which may then develop flowers in the dark. Temperatures also influence flowering favorably,but in the tropics excessive humidity may counteract favorable temperature influence,so

BALD HILL PLOTS.

Plot #1 and #2.

Plot #3.

Seed trees of
Plot #5.

that trees from temperate zones,fail to flower,and the flowering time of indigineous plants falls in the dry season.Again the practice of pruning roots to induce flowering means a reduction of water supply or the formation of water conducting tissue;on the other hand pruning the shoots thereby increasing the water supply reduces flowering."

"Prof.Loew,of Tokio,considers sugar the flower-forming material, and light,temperature,increase and diminution of water supply favor its formation,the latter concentrating the sugar in the plant;hence the remarkable flower show of cherries and plums in Japan,where the climate is the cause of the fall of fruit before ripening,which induces the deposit of the unused sugar as starch and fats in the bark and this concentration accounts for the profusion of flowers(152 flowers on 10 inches of shoot were counted)"

"These considerations may give a clue to the prediction of seed years even in forest trees."

The above is interesting in the fact that in the main points it supports the theory that seed production is influenced by the available water and temperatures.

SEED DISTRIBUTION OF THE WHITE PINE.

The observations on seed distribution as to direction and distance from the seed trees have been made in stands in and about the Cornell University woodlots and also in a number of stands in the surrounding country.Each stand will here be taken up separately.

VETERINARY WOODS.

This woodlot is situated on the south east corner of the University Farm,on the south side of the Slaterville road,at the bottom of a steep north slope.The soil is a clay loam and very rocky.More or

BALD HILL PLOTS.

Plot #5.

Plot #5.

Plot #7.

less reproduction is to be found on all sides of this woodlot,the heaviest being on the north side.South of the woods on the top of the hill is a clump of old pines which have seeded down the hill and a good stand of reproduction has resulted on this north slope.The reproduction about this woodlot may be divided into eight groups,according to the source of the seed.Each group will be taken up in order.

GROUP #1. The seed for this group has evedently come from a group of young seed trees growing in the open,and situated in a north-easterly direction from the main woods.It is indicated on the map as #1. The seed have been distributed in a northerly direction from these trees for a distance of 100 yards in an open formation.

GROUP #2.The seed trees for this group are also in the open and situated due east of group #1.Like #1 the reproduction extends due north for a little less than 100 yards in an open formation.

GROUP #3.This group forms the principal stand of reproduction on the north side of the woods.The seed came from trees along the north edge principally from those on the northwest corner.Within 25 yards of the seed trees the stand is dense,further out it is medium grading into open at an average distance of 40 yards,and extending in a northerly direction almost to the Slaterville road,which is almost 100 yards distant.

GROUP #4.This group is at the east end of the woods and has originated from trees at the northeast corner.The distribution in this case has been in an easterly direction,the reproduction extending in a medium to open formation for a distance of 75 yards.

GROUP #5.This group is on the north slope of the hill to the south of the woods and has evidently been seeded from trees at the top of the hill.From these trees the reproduction extends in a northeasterly for a distance of a little less than 200 yards.At the top of the hill the reproduction is scanty,owing more likely to poor conditions for germination than to lack of seed.The densest reproduction is about half way down the hill,and it gradually grades from dense to medium,and then

POULTRY WOODS.

Reproduction.

Reproduction.

to open formation.

GROUP#6.This and also group #7 are small stands of reproduction to the suuth of the woods.The formation is open and the trees have made poor growth,but it is sufficient to prove that seeds were distributed to the south of the seed trees.

GROUP#8.It is difficult to tell exactly where the seed for this stand of reproduction came from and so it will not be considered.

From this we see that in this woodlot the seeds have been distributed on all sides where seed trees are present,but the principal reproduction appears on the north and east,and on the north slope to the south of the woods.Wherever the seedlings occur they are in somewhat protected locations.This suggests that the seeds are distributed in practically every direction from the seed trees but only become established in favorable locations.

POULTRY WOODS.

Unfortunately for this study the reproduction in this woods has not been permitted to spread into the surrounding fields,and so,although there is a great deal of young stock within the woods itself,it is impossible to tell which trees the seed came from.

SMITH WOODS.

The stands of reproduction about this woodlot may be divided into four groups.

GROUP #1.The seed for this reproduction evidently came from a single tree,situated on the southwest side well within the woods the distribution being in a southwesterly direction.The reproduction in this group is dense next to the woods and extends for a distance of 25 yards. Here the trees become scattered,the greatest distance they extend down the hill being 150 yards.

SMITH WOODS.

Plot #1.

BUTTERMILK VALLEY

Plot #1.

GROUP #2.This is an open stand of reproduction originating from seed blown in a westerly direction from trees situated at the northwest corner of the woods.This reproduction merges with that of group #3 and so the distance od distribution cannot be deffinately determined but is probably less than 100 yards.

GROUP #3.This seeding is at the bottom of the hill to the west and has been seeded by trees on the north side of the Varna road.The seed were distributed in a southerly direction and the resulting reproduction extends for a distance of 75 yards in open formation.

GROUP #4.The seed for this group of reproduction came from several quarters.A part from the seed trees in group #2,a part from the seed trees of group #3,but the principal seeding was evidently from a row of trees extending from the Varna road to Fall Creek in a north and south direction,the south end of the row being just across the road from the northeast corner of the woodlot.The seeding therefore has been almost due west,and has resulted in a fairly even,dense to medium stand, extending for a distance of nearly 200 yards.

BUTTERMILK VALLEY ABOVE THE MILL POND.

PLOT #1.This is a dense stand of reproduction on a northwest slope.The seed were distributed up the slope in a southeasterly direction for a distance of 50 yards which marks the top of the ridge.There is no reproduction on the top of this hill,but over the ridge at a distance of 100 yards from the seed trees there is a small group of seedlings.Evidently conditions on the top of the ridge and on the southeast slope were adverse to the establishment of seedlings,since there is no reason to suppose that seeds were not distributed in these locations and yet were distributed over the ridge and into the valley below.The soil here is a gravel loam of glacial origin.

BUTTERMILK VALLEY.

Plot #3.

Plot #4.

PLOT #2.This plot is situated on the flood plain of Buttermilk Creek,just above the pond.The soil is principally silt and sand deposited by the creek,and is very rich.The reproduction has arisen from seed from several sources,but in every case the seeds have been distributed toward the east at a maximum distance of 75 yards.This stand is for the most part of medium density.

PLOT #3.This is a small plot south of plot #2.The seeds have been distributedin a southerly direction,resulting in an open formation for a distance of 50 yards.

PLOT #4.This plot of reproduction occupies the flood plain of the creek at a point above plot #2,and extends up the north slope of the ridge to the south.The plot is bounded on the west by young seed trees ,which have seeded in for a distance of 25 to 50 yards on those sides. The principal seeding has been done by a group of seed trees at the north-west corner of the plot,which have distributed seed for at least 100 yards in a south easterly direction,and a single large seed tree growing in the open,which has seeded in a direction slightly east of south,for a distance of 190 yards,which takes it nearly to the top of the hill.This is a most remarkable case of seed distribution as the seedling highest on the hill is almost as high as the top of the seed tree from which the seed must have come.

TURKEY HILL REGION.

PLOT #1.This plot of reproduction is in a hay field and owing to the cutting of the field for hay the seedlings are only little bunches of leaves close to the ground,but they indicate fairly well the distribution of seed in this location.The field is bounded on the north, south,and west by woods,and on the east by a road.On the south boundary and curving around to the west is a small brook.The seed trees are located along the south boundary and the seeds have been distributed in a

northerly direction for a distance of 140 yards.The reproduction is evenly distributed in an open stand,which would probably be dense if it were not for the repeated cuttings.

PLOT #2.This plot is located due east of plot one,on a steep slope with a northwest exposure.The principal stand of reproduction is west and down the hill from the seed trees,and extends for a distance of 150 yards,The dense stand is within the first 50 yards,and then it grades into medium and then open formation.Seed has been distributed toward the north for a distance of over 180 yards.In this direction the land is occupied by brush and young hardwoods and the chance of seedlings becoming established has been poor.

PLOT #3.This plot of reproduction is situated on the north slope of Turkey Hill and the seed all evidently came from a single tree 200 yards from the top of the hill.The seeding has been up the hill in a southerly direction and reaches the summit in a medium to open stand.

PREVAILING WINDS DURING SEPTEMBER,OCTOBER,AND NOVEMBER.

Records of the winds prior to 1900 are unavailable,but the following table will show the conditions since that time.It will show that the winds in this locality,during the periods of seed distribution are very variable,and that if the land were perfectly level and the trees were in the open we should find the seed distributed around the tree in every direction,but principally toward the northwest and southeast.In this study we have found reproduction in almost every direction from the seed trees,but always in a location suitable for its establishment. In every case,however we found the reproduction more in one direction than in the others.This may be explained in one of two ways;either the conditions were more favorable for the establishment of seedlings in that direction than in the others,or the topography of the land cut off

cut off the wind in certain directions but permitted full swing in another. Thus local topography seems to be more responsible for the direction of distribution of white pine seed than the prevailing winds.

Year	White Pine Seed Crop	Annual Prevailing Wind.	Sept. Prevailing Wind	Oct. Prevailing Wind	Nov. Prevailing Wind
1899	None.			S.E.	N.W.
1900	"	N.W.	N.W.	"	"
1901	"	"	S.E	"	"
1902	Abundant	"	"	N.W.	S.E.
1903	None	S.E.	"	"	"
1904	"	N.W.	"	S.E.	"
1905	"	S.E	"	"	W
1906	Good	N.W	N.W.	"	N.W
1907	None	"	"	N.W	"
1908	"	"	S.E	S.E.	S.
1909	Fair.	"	"	N.W	S.E.
1910	None.	"	N.W.	"	N.W.
1911	"	"	"	S.E	S.E.
1912	"	"	S.E.	N.W	"
1913	"	"	"	"	N.W.
1914.	Fair.	"	N.W.	"	S.E.

CONCLUSIONS.

The conclusions of this study may be summarized as follows:-

1. The periodicity of seed years may be explained to some ex tent by the variation of available soil water from year to year.

2. Different species, having different moisture requirements, are influenced in different ways by these variations, thus accounting for the fact that all species do not seed the same years.

3. Seed is distributed in all directions from the tree if local conditions do not interfere.

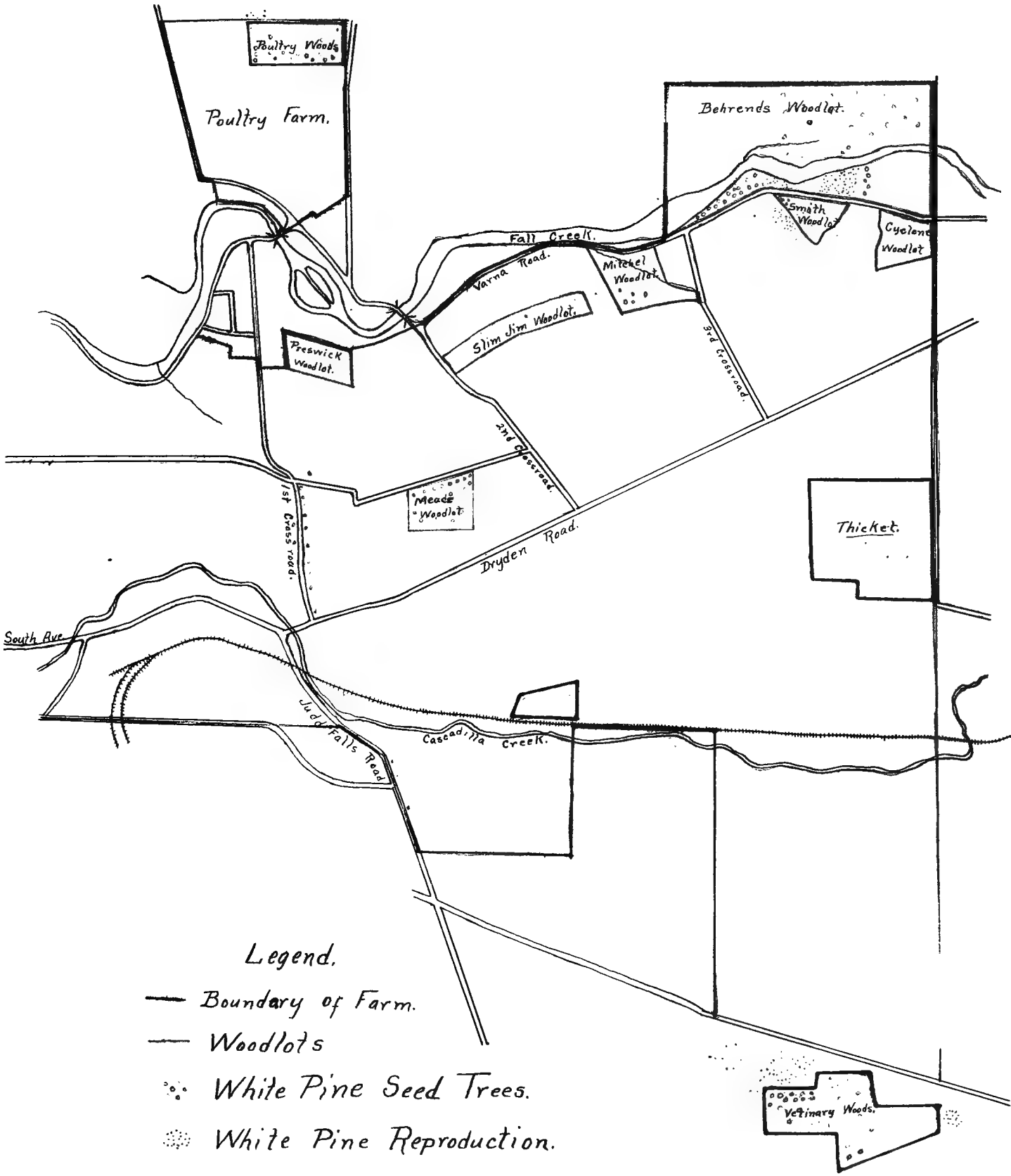
4. The direction of seeding is controled more by local topography than by the direction of the prevailing wind.

5. The presence of reproduction on one side of a group of trees and its entire absence on the other may oftener be accounted for by the presence

of adverse conditions for the establishment of seedlings on that side than by lack of seed distribution in that direction.

Map of Cornell University Farm.

Showing Woodlots, Seed Trees, and Patches of Natural Reproduction.



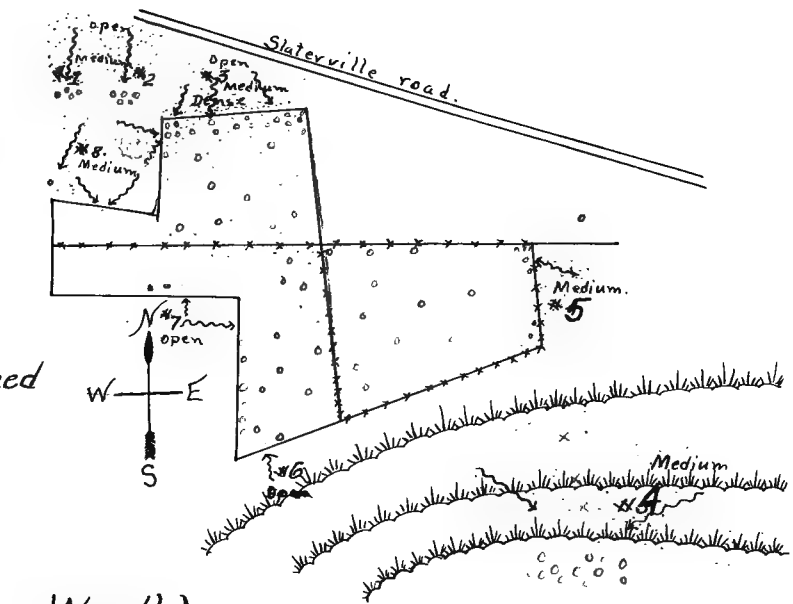
Veterinary Woods.

Legend

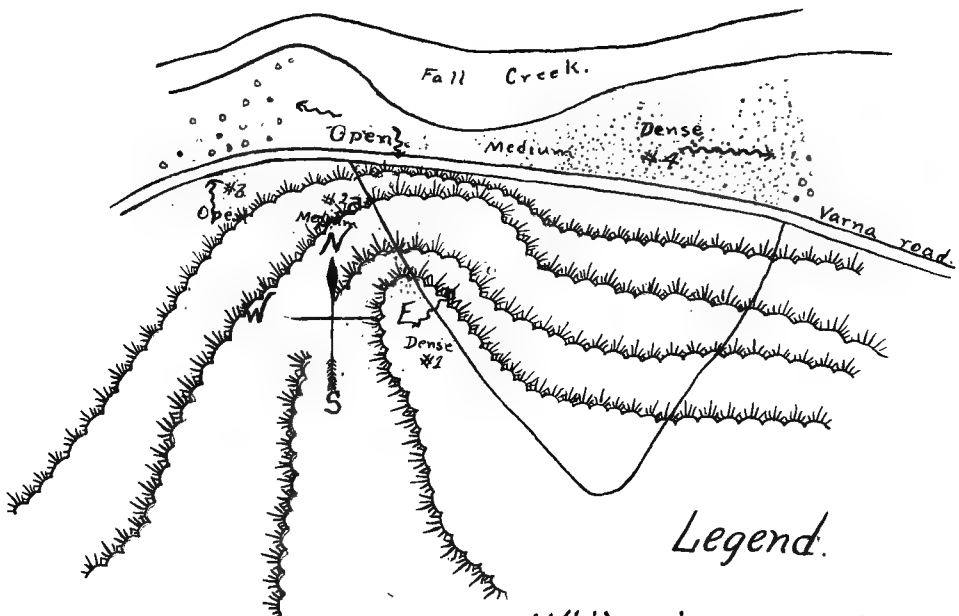
White pine seed trees.

White pine reproduction.

Direction of source of seed



Smith Woodlot



Legend.

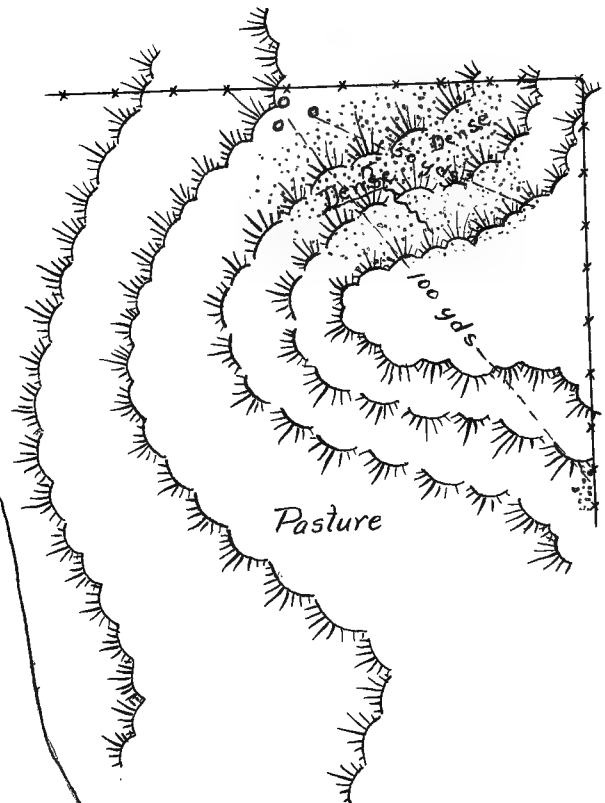
White pine seed trees

White pine reproduction.

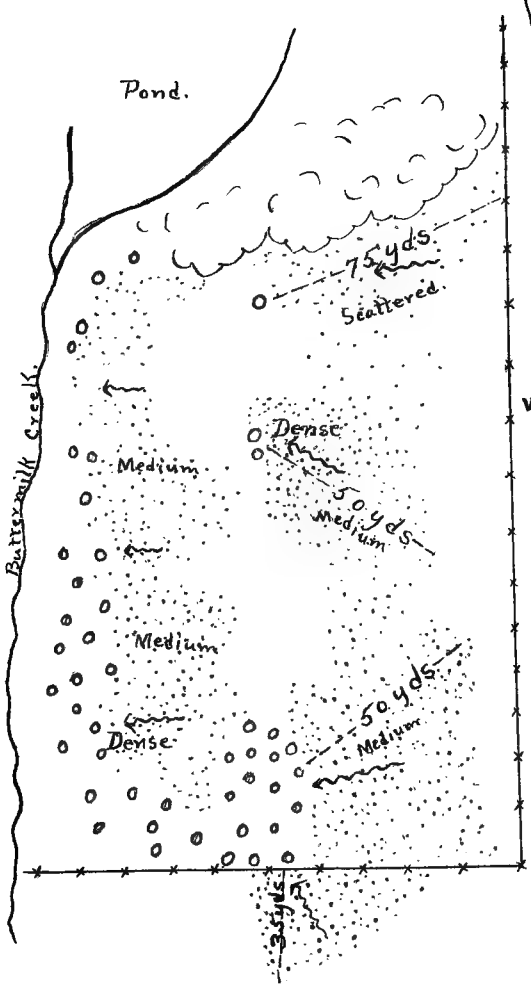
Direction of source of seed.

Buttermilk Valley

Plot *1



Plot *2.



Legend.

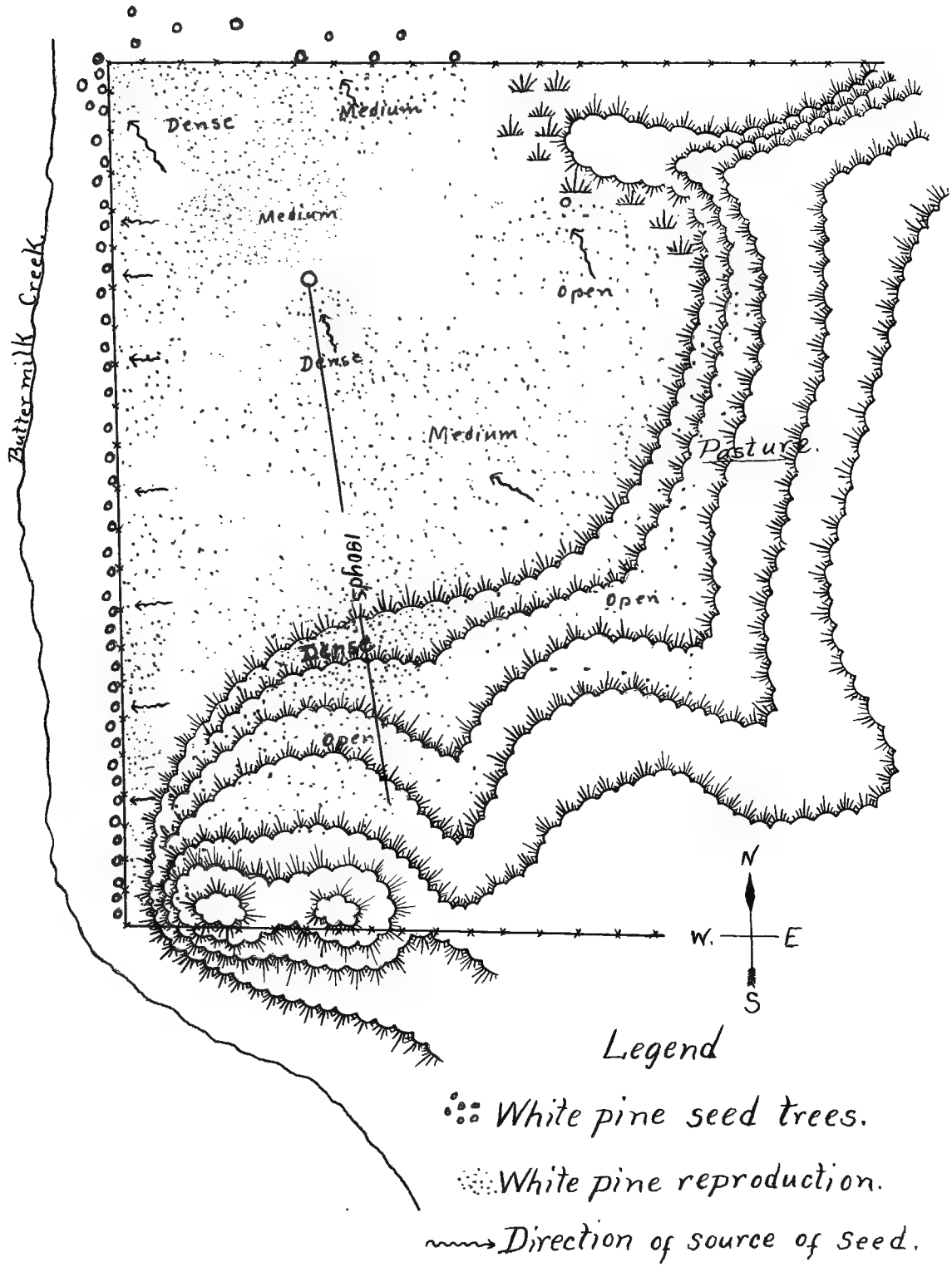
White pine reproduction.

White pine seed trees

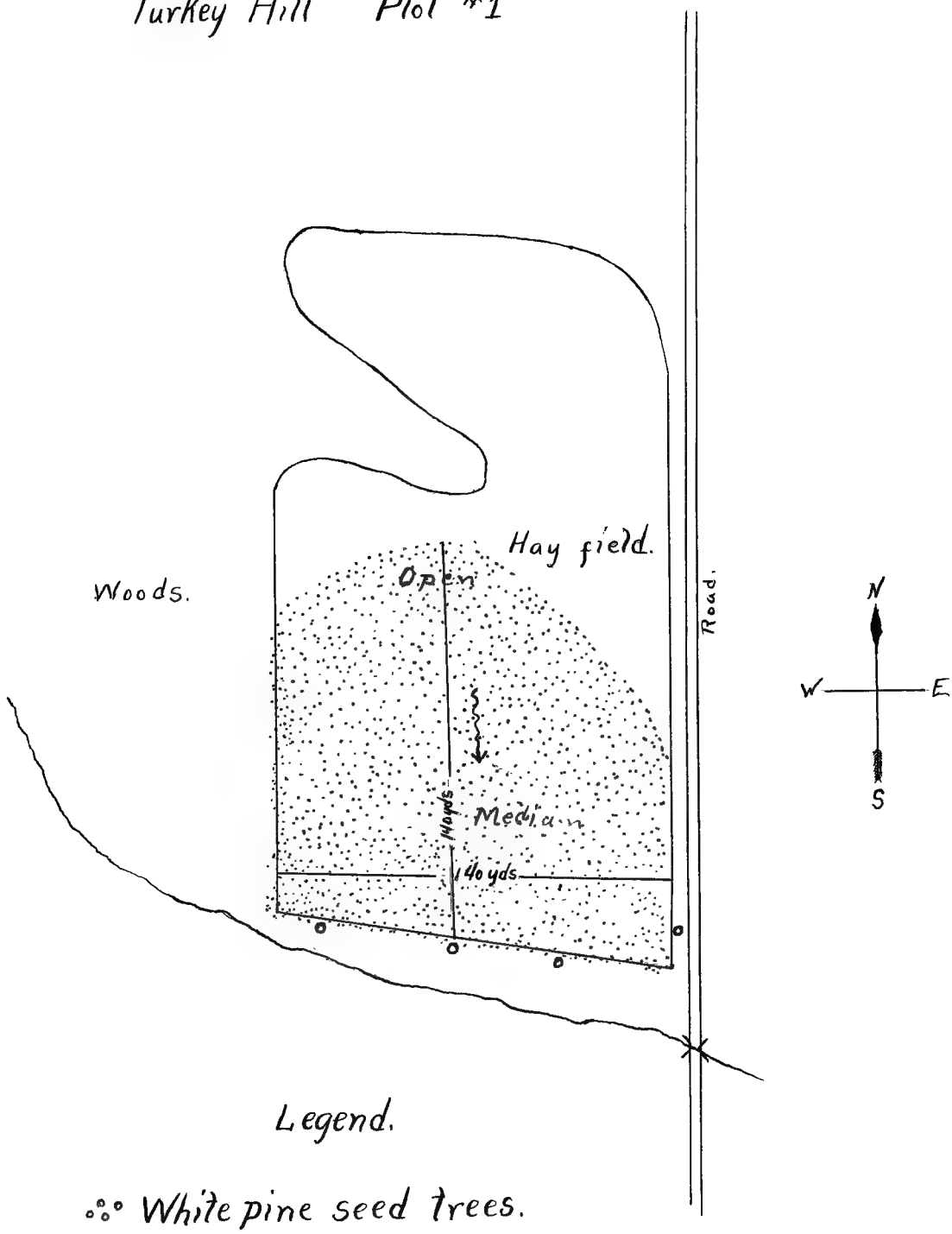
Direction of source of seed.

Buttermilk Valley

Plot #3.



Turkey Hill Plot *1



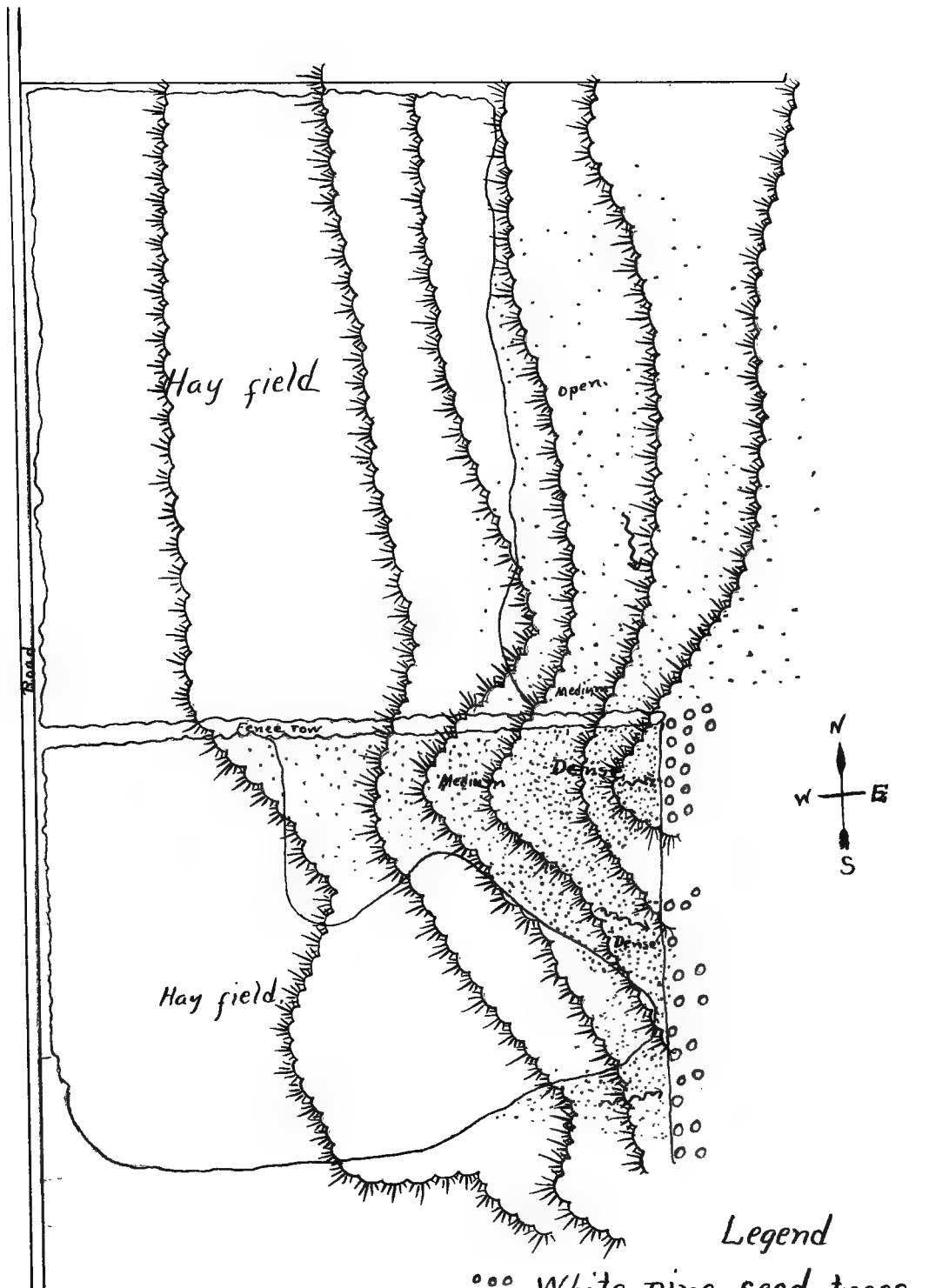
Legend.

White pine seed trees.

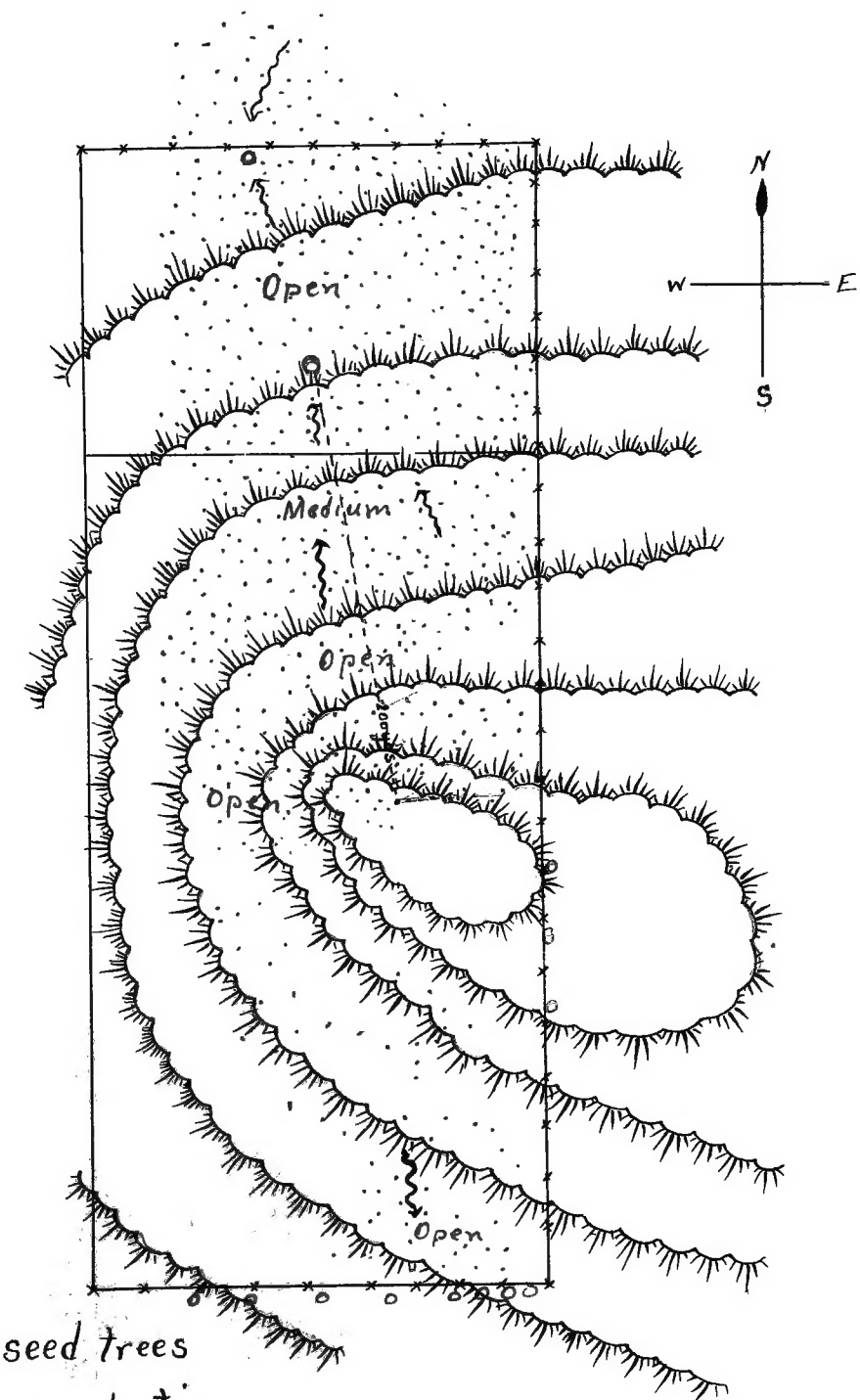
White pine reproduction

Direction of source of seed.

Turkey Hill Plot *2.



Turkey Hill Plot # 3.



Legend.

White pine seed trees

White pine reproduction.

Direction of source of seed