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NOTES ON THE CHESTNUT BARK DISEASE (*DIAPORTHE PARASITICA*, MURRILL) IN PETERSHAM, MASS.

J. Kittredge, Jr., 1913

The following data were collected in October and November, 1912, at Petersham, Massachusetts. The object of the study was to determine the present status of the chestnut bark disease in and about the Harvard Forest and to secure any possible information about the habits and appearance of the fungus which might indicate the means by which it is or is not distributed.

The disease was first noticed in Petersham in the fall of 1910 by Professor J. G. Jack of the Harvard Forest School, along a road not over a mile from the School and about three and one-half miles north of the village of Petersham. In August and September, 1911, Professor A. H. Graves, then in the Bureau of Plant Industry, found infection at several places in and about Petersham, particularly along the Athol Road. At that time he marked infected trees in several localities and carefully examined others near them, noting whether they were probably infected or apparently sound. The locations of a number of these infectious were pointed out to the writer by Professor E. E. Carter of the Forest School.

In this study the infection was viewed from the forester's standpoint, with little or no reference to the morphological or physiological characteristics of the disease. At the time of the study, only the winter fruiting bodies were in evidence.

In the first part of the study, data was collected as follows: All trees showing any evidence of infection were first classified in three groups: —

I. Trees surely infected (with the fruiting bodies developed).

II. Trees probably infected (with dead branches and persistent dead leaves or burrs or badly sunken bark).

III. Suspicious trees (with the persistent leaves or sunken bark less markedly developed than for Class II trees).

Trees which were apparently uninfected were entirely disregarded. For all trees included in the above tree classes, the following data was noted: —

1. Careful geographical location.
2. Origin, seedling or sprout.
3. Diameter at breast height.
4. Crown class; whether dominant, co-dominant, intermediate, overtopped, or suppressed.
5. Distribution of infection about known centres, and relations of crown and distance between infected specimens (numbered and oriented sketches).
6. Location of trees relative to site, aspect, forest type, and density of surrounding stand or degree of isolation with history of its cause.
7. Probable length of time since infection started.

The field work consisted in the inspection of trees, along roads, on strips through the woods, and around infections which had been previously reported. After some data had been secured in this way, the rest of the time was devoted to a detailed study of one stand on the Harvard Forest, which will be described later.

The infection is now almost universally distributed in the town of Petersham. Surely infected trees were found from the Athol line on the north to North Dana and New Salem on the west, and two miles south of the village toward Barre. The region to the east of the village was not examined.

Origin seems to have had no effect on the susceptibility of chestnut to the disease. The data obtained showed that the total number of infected sprouts in Classes I and II exceeded the total number of infected seedlings in the ratio of two and one-half to one, but this difference is easily accounted for by the predominance of sprouts over seedlings in the whole chestnut growth of the region. When all trees are included as a basis of comparison, the ratio is about three and one-half to one. This is, however, in a stand typically of sprout origin. On the special plot, the insignificance of the influence of origin is more evident, for of 219 trees of seedling origin, 32 (14.5 per cent) were surely infected, and of 747 trees of sprout origin, 97 (13 per cent) were surely infected. Trees in Classes II and III have been omitted from consideration

here because they were so numerous in this stand, where so many sources of infection were in close proximity that origin could have no effect on their susceptibility in any case.

Proximity to roads and highways has no apparent effect on the distribution of the disease. It occurs right next to the roads on isolated roadside trees, but on the other hand, the worst infection examined was more than one-quarter of a mile from any road and fully a mile from the nearest highway used by automobiles. Whole stands, more isolated from roads than this one, are rare in the vicinity.

The relation of appearance of fruiting bodies to side of trees was also studied. When the infection is three or sometimes only two years old, it has almost always girdled the tree, so that the fruiting bodies appear on all sides of the stem. If, however, the infection is more recent, they usually appear on the south or south-west side of the tree, probably owing to the greater warmth of the sun's rays on that side. In two cases where the trees were heavily shaded to the S. W., the fruiting bodies were observed only on the unshaded N. E. side. Of 112 trees, showing the fruiting bodies only on one side, the different sides were represented as follows: —

	S. or S.W.	N.	E.	W.	Total
Number of trees	93	3	5	11	112
Percentage of total	83	3	4	10	100

Grouping the trees noted in three inch diameter classes, it appears that trees from three to six inches D B H show at least the matured results of infection quickest and that trees below six inches are more liable to infection than those of larger diameter. The figures somewhat exaggerate the actual conditions owing to the predominance of the number of small trees among those examined, but the numerical ratio of small to large infected trees appears distinctly larger than the ratio of all small chestnuts to larger ones on the areas examined.

The fungus will as readily attack a healthy dominant tree as a feeble suppressed one. Frequent cases were noted in which trees grown in the open pasture lands or along roadsides bordered by

meadows, under the best light conditions for vigorous and complete crown development, were badly attacked. The figures seem even to indicate that it prefers the dominant trees, for of the 231 surely infected trees, sixty-three per cent were dominant or co-dominant, seventeen per cent were intermediate, and twenty per cent were over overtopped or suppressed; and of the 524

INFECTION BY DIAMETER CLASSES

Diameter Class	Surely Infected		Probably Infected	
Inches	Number	Per cent	Number	Per cent
0 –3	59	26	261	50
3 –6	106	46	223	42.5
6 –9	52	22	33	6
9–12	11	5	5	1
Over 12	3	1	2	0.5
Totals	231	100	524	100.0

probably infected trees, forty-three per cent were dominant or co-dominant, twenty-three per cent were intermediate, and thirty-four per cent were overtopped or suppressed.

No consistent relation between centres of infection and more recent infection from those centres could be established, although it was very evident that some areas were more heavily infected than others. Descriptions of the distribution about two rather distinct centres will best illustrate the lack of a definite relation as to direction.

1. A seed tree left on flat after cutting in 1909; now badly infected and dying. There is an alder swamp to the west and three year old sprouts over the open country to the S. E., and N. W. Three surely infected sprouts, which might under the circumstances have been infected by wind dissemination from this tree, are situated, (*a*) 45′ north, (*b*) 50′ east, and (*c*) 115′ S. E. There is probable infection scattered over much of the area.

2. Another flat, three hundred yards northeast of the first one. A mixed hardwood and pine stand which had been thinned and was surrounded by pure pine and swale. This case shows a distribution about centres to the W., S. W., and N.

In neither case is there any possibility that the spores could have washed from the central tree to the others. The diseased trees on the special plot show further examples of centres and the surrounding infection with no constant relation between the two. Certainly in these cases, with the possible exception of the first one, there is no distinct spread to the N. E. or S. E. as might be expected if the fungus spores were primarily distributed by the prevailing westerly winds of the region.

There is always the possibility in this connection that it is not distribution about centres at all which we see. The centres of infection are not always easy to determine. Having been determined, the question rises, are the nearer surely infected trees, *i. e.*, those producing spores, the result of infection by spores which were produced on the original tree ? In the majority of cases the writer thinks not, but rather that they were infected before the supposed centre of infection had reached the point of producing spores. This seems the more plausible when badly infected, isolated trees are found with no other chestnuts within one hundred feet and those that are nearest apparently sound.

Petersham is in a transitional forest region where the northern pine overlaps the southern New England sprout-hardwood region. The types are usually distinct. Thus, there is an excellent opportunity to study chestnut in a variety of surroundings as regards type and to see if trees in one type seem more immune to the disease than those in another. Chestnut, of the forest trees, is only exceeded in abundance by white pine and red maple. It occurs on any well-drained soil, either in stands, largely of sprout origin, or at the other extreme, isolated in the open pasture land which is slowly seeding in to pine or even in stands of ninety per cent pure pine. The sprout stands may be of widely varying mixtures of hardwood and chestnut, or they may contain chestnut up to sixty per cent of the stand by number or a much larger percentage of the dominant trees. Trees and stands of all ages up to eighty years are represented and scattered individuals may be considerably older.

There appeared to be no relation between susceptibility to attack and the types in which chestnut occurred. Trees with fully developed fruiting bodies were found under all the conditions in

which chestnut grows in the region, — in the open pastures; along roadsides; isolated trees in pine stands; isolated trees in stands of red maple, gray birch, and aspen; in mixtures of red oak, chestnut, ash, and maple; and in stands classified as chestnut slopes. Certainly no type provides immunity from the disease, although the data collected indicates, as will be shown later, that presence in or proximity to certain types tends to increase the liability to infection.

The frequent discovery of dead or badly infected trees in or near stands of pure pine or pine in mixture led to the detailed examination of all the chestnuts over an area where infection had been found by Professor Graves in 1911 and where many trees are now dead or very badly infected. The stand was a sprout-hardwood slope, with easterly aspect, in which chestnut formed thirty per cent to forty per cent of the stand. It was bounded on the north by twenty year pine; on the west by a strip of twenty year pine with open, grassy land beyond over the crest of the hill; at the foot of the slope to the northeast, there was a patch of pine and hemlock and southward, a maple swale followed the brook. Five fifty foot strips were run down this slope, parallel to the north boundary, the first three adjacent to the pine and the last two at intervals of one hundred feet. Every chestnut on these strips was inspected and placed in one of four classes, Class IV to include all apparently uninfected trees. The rest of the data was noted as previously described. The strips are numbered successively from the north at the edge of the pine to the south.

Strip number	1		2		3		4		5	
	No. of Trees	Per cent	No. of Trees	Per cent	No. of Trees	Per cent	No. of Trees	Per cent	No. of Trees	Per cent
Class I	47	*27*	30	*19*	24	*12*	19	*9*	9	*4*
Class II	46	26	50	31	73	38	101	46	71	31
Class III	38	22	46	28	81	42	76	34	73	32
Class IV	44	25	35	22	15	8	25	11	73	32
Totals	175	100	161	100	193	100	221	100	229	100

The progressive decrease in the percentage of surely infected trees as you go further from the pine at the north edge is very striking.

The results shown in Classes II, III, and IV, although somewhat contradictory, are comparatively insignificant, because the large number of spore-producing trees in the stand for the last year or more would be sure to cause recent infection in most of the chestnuts on the area through any agency. Hence, they are of little value as indicating the primary means of distribution to new localities. To further test this same idea, the data from this area were divided into three strips, perpendicular to the first five, so that the first was adjacent to the pine at the top of the slope, the second, along the central portion, and the third, along the foot, next to the hemlock and maple swale. These strips cover approximately one hundred and fifty feet in width.

Strip number	1		2		3	
	Number of Trees	Per cent of total	Number of Trees	Per cent	Number of Trees	Per cent
Class I	61	*17*	20	*8*	51	*17*
Class II	166	47	82	32	114	37
Class III	91	26	124	48	101	33
Class IV	35	10	32	12	41	13
Totals	353	100	258	100	307	100

In this table again, the number and percentage of surely infected trees are greatest in the strips adjacent to the pine or swale.

Outside of this area also, the Class I trees were found most frequently near coniferous stands. Since notes were made on the distance of infected specimens from coniferous stands only in the latter part of the study only sixty-three trees are included in the following table: —

Location		In pure Pine Stands	Within 100′ of Pine	100′–500′ from Pine Stands	500′+ from Pine Stands	Totals
Class I	Number of Trees	4	28	20	11	63
	Per cent of Total	6	44	32	18	100

This data as a whole would seem to show that it is more than mere coincidence that the disease occurs more frequently in or

near coniferous stands. The most plausible and, so far as the writer can see, the only reasonable explanation of such a distribution is by bird agency. It is a well-known fact to any one who has ever watched the habits of birds that they are more abundant on the borders of woods, especially evergreen woods, or where there is a change of type, as at the edge of a swampy tract. If then, both the birds and the disease are more abundant at the edges of coniferous stands where the hardwoods or chestnut adjoin them, and no other agency will account for such a distribution of the disease, why should the two facts not be cause and effect?

The data on the location of fruiting bodies on the tree as regards height seem to point to the same conclusion. Actual notes taken in the latter part of the field work show that when the infection was still comparatively local on the trees, it usually had started on the main stem, somewhere in the middle third of its height. The writer feels certain that, if further data on this point had been secured, it would have shown the same results. The data secured are as follows: —

Position on Tree	Middle third	Above	Below	On a branch only	Total
Number of cases	28	1	5	3	37
Percent of total	76	3	13	8	100

In three cases, in which the trees were climbed to examine infections which were confined to branches, the fruiting bodies were on the upper sides of the branches only. In only two cases did the infection seem to have started round a wound. These figures again indicate a distribution by birds, and primarily by the creeping birds, such as the creeper, nuthatches, and woodpeckers, which spend most of their time on the trunks and big limbs. Although these birds are permanent residents in Petersham, there is a decided migration of them in spring and fall as those that are residents further north or south pass through. This would explain the rapid spread of the disease over long distances and also its peculiar local distribution.

In order to discover any possible effect of distribution by wind, the groups of sprouts, in which not all of the trees were surely

infected, were considered separately. This furnished data for the following table which show the relative frequency with which the infected sprouts were found in different positions in the groups.

Position in group	N.	N.E.	E.	S.E.	S.	S.W.	W.	N.W.	Central
Number of cases	2	4	3	12	6	5	2	4	2

These results surely show that a prevailing southwest or northwest wind is not the prime factor in the distribution of the spores.

The disease is a serious menace to the future production of chestnut in the region. Of about 700 trees examined (counting groups of sprouts as single trees), 122 or seventeen per cent had infection which seemed to be two or more years old; nine or one per cent showed a probable three year old infection. Several trees which were examined fifteen months previously by Professor Graves and considered sound at that time are now badly infected. On the special tract, where the infection was as bad as any that the writer saw, in a stand with a large proportion of chestnut, the results were as follows: —

	Number of Trees	Per cent of total
Dead†	28	3
Class I	129	13
Class II	341	35
Class III	317	32
Class IV	192	20
Totals	979	100

From these figures, it is evident that the chestnut bark disease is a very serious and imminent menace in this region. Estimating conservatively and judging from the fact that trees, dead at present, have not been infected more than three years, thirteen per cent of the trees in this stand will be dead in two years and twenty-five per cent to thirty per cent in three years.

† Dead trees are also included in Class I.

From the foregoing data, it is possible to sum up the following tentative conclusions as to the habits and status of the fungus. It is fully realized that the basis for most of these tentative conclusions is very meager.

1. The disease is well established and widely distributed in the town of Petersham.

2. Sprout or seedling origin has no effect on the susceptibility of chestnut trees to the disease.

3. Proximity to highways and roads has no apparent relation to the infection.

4. The fruiting bodies appear first almost always on the S. or S. W. sides of the trees.

5. Trees over six inches in diameter at breast height are somewhat more resistant to the disease than those below that size.

6. There is no definite direction of spread about centres of infection.

7. The location of infected trees in partially infected groups of sprouts shows that wind is not the prime factor in the distribution of the spores.

8. Dominant trees are as likely if not more likely to be infected than suppressed ones.

9. Lesions usually appear first in the middle third of the main stem.

10. The disease occurs in any type where chestnut forms a part of the stand. Infection is more abundant, however, near the margins of coniferous stands, which indicates that birds may be a very important, if not the primary agent, in its distribution.

11. At the present time, the worst infection seen shows thirteen per cent of the chestnuts badly infected so that they will die in two years.