

A FUNGUS DISEASE OF CONIFERS RELATED TO THE SNOW COVER

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UNTIL towards the close of the last century the vast forests of America seemed to be sufficient for all demands that might be made on them for all time. Fear that such might not be the case was first aroused by obtruding evidence of rapid depletion of the White Pine. This found expression in active propaganda for replacement by planting. But a resultant planting campaign scarcely began when it received an unforeseen check through the announcement about 1910 that a potentially dangerous blister rust had been imported in nursery stock and had been widely distributed. In consequence of the thorough establishment of that unwelcome pest even the most optimistic nowadays agree that the restoration of some of our White Pine forests at least will involve arduous, vigilant and expensive effort.

When the supply of White Pine waned we turned to less valuable woods such as Spruce and Fir. As the years have gone by the demand for them has steadily mounted because continually additional uses have been found for them—as for the manufacture of paper and viscose. Consumption has proceeded at an accelerated pace, so that in turn their early exhaustion is no idle threat. To forestall an eventuality that would be so disastrous to the welfare of great industries, to communities directly dependent on them, and to the public in general, it has been for some time apparent that measures of economy and replenishment must be devised and practised. Planting, better management, and closer utilization have been proposed as means affording a solution, and beginnings have been made along these lines. But once again, in certain regions there has loomed up an imminent frustration of planting policies because of the appearance of an unexpected disease.

This disease has been one of the subjects of my researches during the last two years, and the purpose of this paper is to present an account of its nature, cause, origin and control. It may properly be named “Phacidium blight of conifers.”

My attention was first called to Phacidium blight during the summer of 1923 in a large spruce nursery whose output runs into the millions of trees each year, though I afterwards knew that that was not my first contact with it. I had long known it on Fir, though not its cause, and have since found it in various parts of the northeastern United States and eastern Canada on Fir, the Spruces, and occasionally on Pines and Arbor-vitae. Its attack is *en masse* on leaves of all ages, but only on those needles that lie below the snow cover. Its virulence is so severe that few Fir or Spruce trees once involved escape destruction unless their leaders are well above the surface of the snow.

The affected parts are a soft and more or less glaucous brown color. In closely planted nursery beds it occurs in subcircular patches up to two feet

or more in diameter, or in strips where the plants are in fully separated lines. As for older trees, masses of branches on one side or all within certain horizontal planes are browned; and if they have suffered in previous years the newly browned foliage is contiguous to old more or less completely defoliated branches, or to those that are covered with withered and whitened needles. Leaves of all ages are equally liable to attack. Diseased needles of White Pine drop during the first summer, those of Fir and Arborvitae carry through the following winter, while those of the Spruces likewise commonly adhere throughout the winter unless too much subjected to drought or wind or other disturbing agencies.

The disease as first seen by me in the nursery was on two and three-year old beds of White Spruce. The latter had suffered the year before and were mostly a complete loss. But they, like the former, were said to have entered their first winter perfectly green. The brown needles showed submerged black dots, evidently incipient fungus fruits, but there was no evidence at that time to show that the fungus might not be purely secondary. The blight, whatever its cause might be, had not spread subsequently to the uncovering of the beds through the melting of the snow a few months previously.

The losses and expansions of invasion in the springs of 1924, 1925 and 1926 were reported to be continually mounting at a rapid rate, and those of 1926 were so enormous that the future of the nursery was jeopardized. The problem was then actively taken up, and during 1927 visits were made in the spring just as the snow was leaving, again in midsummer, and finally towards the end of the fall. At my suggestion, Mr. G. G. Cosens, a resident forester, marked the limits of a number of spots in the beds and staked individual diseased trees here and there in the transplant lines in the fall of 1926, so that in the following spring we might have definite information as to whether or not there was a spread from these foci.

To the symptoms just recorded, may be added the appearance of sub-epidermal disk-like apothecia in the fall on needles browned the preceding spring. These are exposed by the irregular dehiscence of the overlying epidermis, and from them there is spore-discharge in mild, damp weather until winter sets in. There has also been noted an almost constant occurrence of black microsclerotia on the affected needles in the spring. Likewise, observation at the right moment in the spring reveals a more or less evident covering of white mycelia on the browned foliage just as the snow melts away.

CAUSE

After becoming familiar with the symptoms, the next step was to determine the cause. In view of the time at which the disease manifested itself it was natural to suspect winter injury. But with knowledge of the continuous aggravation of the malady throughout a period of years, such an explanation was not convincing. Since the grass and the low-lying vegetation everywhere in that region, as well as the brown spots, are cover-

ed with a white cobwebby gauze as the snow disappears, it was suggested that this might furnish a clue. But the molds on the grass were found to consist of the mycelia of a few species of fungi that apparently were purely saprophytic. Several experiments and observations, however, have demonstrated beyond question that the disease is infectious and contagious and that it is due to a fungus. These are as follows:

1. The mesophyll of the browned needles from the first is occupied by intercellular hyaline hyphae and cultures show that it is always the same fungus.

2. The spread of the disease from spring to spring is to contiguous foliage.

3. Wherever the needles of adjacent susceptible conifers come into contact with diseased foliage they, too, are likely to be browned.

4. From the preliminary markings made in the fall of 1926 in nursery beds and transplant lines there was an extensive spread showing in the spring of 1927.

5. From the reported history of the disease in two nurseries, one in Quebec and the other in New England, we know with reasonable certainty that it began in both at recognized limited points, and its spread from them has been disturbingly noted.

6. Experimental plots were staked out in nursery beds, transplant lines and plantations—about 30 acres in all—during the season of 1927, and the diseased spots and trees were marked. In all cases a spread was revealed in the spring of 1928. The lateral spread in the nursery plots affords a striking illustration. The areas diseased in ten 2-year old beds of White Spruce in 1927 ranged from 3% to 40% in extent, with an average of 18.4%; in the spring of 1928 the range was from 12% to 85%, with an average of 47.2%.

7. Net bags of diseased Spruce needles were hung in the crowns of healthy Spruces in a disease-free plantation in November, 1927, just at the onset of winter, all below the snow line (12 experiments). In the spring of 1928, as the snow fell away, these bags were seen to be the centres of subspherical masses of brown foliage a foot to two feet in diameter, and nowhere else in the plantation did the disease develop.

8. Mr. G. D. Darker similarly suspended bags of diseased Balsam Fir in Balsam Fir, Hemlock, and White Pine trees in the fall of 1927. Browning showed in the adjacent foliage and not elsewhere in the spring of 1928.

A study of the fungus proves that it a species of *Phacidium*. Morphologically the ascospores are in general like those of *Phacidium infestans* but there are certain features in connection with the fructifications, the mycelial cultures, and the pathogenicity that deter me from deciding finally whether or not the form on Spruce may be varietally different, and whether or not the forms on Spruce and Fir may always be varietally the same. So far as can be learned from the literature and through correspondence,

P. infestans is known only on *Pinus sylvestris* in Europe. The only record in America is by Weir, who found a parasitic *Phacidium* on certain western species of *Abies* and on Douglas Fir which he called *P. infestans* var. *Abietis*.

All of the means of dissemination have likewise not yet been cleared up. It seems obvious that primary infection is by means of discharged ascospores in the fall. These germinate readily without a resting period. It is of course possible that some of them may carry through the winter and cause infection in early spring. It also seems likely that the microsclerotia referred to above are a phase of the fungus and that they may cause infection. It is certain that a very important cause of infection is the mycelium in the browned needles. During the latter part of the following winter, for a few weeks before the snow departs, this mycelium grows out under the snow over to adjacent foliage and enters dormant healthy needles. Foliage in contact with browned branches has been dug up in late winter and at that time these phenomena were beginning to show. The temperature in the crust-covered air pockets around branches or small trees varied from 36 to 43° F. on bright sunny days during the period of thaws. Mycelial spread was also seen to advantage in the thawing season in beds covered over by a low platform of boards.

CONTROL

The question of control was naturally uppermost in mind from the first, and every new acquisition of knowledge regarding the cause of the disease and the behavior of the pathogen was treasured for its possible bearing on an efficient method of control. The European literature had nothing to offer on this matter for it was acknowledged by European pathologists that no effective means had been devised for combating *P. infestans*.

Acting on general principles it seemed advisable to practice thorough sanitation in the nursery so far as possible. Hence as a first measure badly diseased beds were treated with a strong lime-sulphur spray and turned under with the plow. Then an extensive program of spraying experimentation was projected. For this purpose thirty-seven beds of White Spruce and nine plots of 2-1 (2 years in nursery beds, 1 year in transplant lines) transplants were reserved. The latter measured 10,000 square feet each, with about 40,000 young trees in each plot. These experiments consisted of sprayings with lime-sulphur (dormant) of various strengths, part in late spring and part in the fall up until the first snows fell; in some the browned plants were first eradicated, in others they were not disturbed. A few plots were not treated, but left as controls. The results have been highly gratifying. Removal of the diseased stock before spraying proved to be of no value. Spraying in the spring was likewise of no effect. On the other hand spraying in the late fall with lime-sulphur gave perfect control. One very interesting result noted was that browned, unpulled spots, not only showed no spread after fall spraying, but some of the appar-

ently dead plants revived to the extent of unfolding meagre new foliage in the following spring.

Having discovered the ascosporic fructifications in the fall of 1927, and knowing of the mycelial habit of spread, it was surmised that if spraying were of any avail the fall would be the proper time to make the application. So the beds throughout the nursery not reserved for experiment were treated to a dormant lime-sulphur spray. The nursery uncovered in the spring of 1928 without a blemish and continued so for the rest of the season. For the first time in years the nursery was free from the *Phacidium* blight.

In attempting to control the blight on the plantations several procedures are being followed. For planting, only positively healthy stocks are used, and such plants are first sprayed or dipped in lime-sulphur. In some of the established plantations the diseased stock was pulled by hand and carried in sacks to canvas-lined wagons, removed and burned. The full value of this latter measure cannot be fully appraised for another year or two, but success is anticipated. It is possible that thorough fall spraying of diseased trees in the plantations might be successful and practicable; if so a large proportion of affected trees would be conserved; an experiment of this type has been projected.

At the suggestion of Mr. Ellwood Wilson, diseased branches were removed from a number of six or eight-year-old trees in the fall of 1927 and burned. Some of these trees showed a little browning in the spring of 1928, but several came through clean.

The cost of fall spraying in the nursery and of removal of diseased plants from the plantations is trifling.

DISTRIBUTION AND ORIGIN OF PHACIDIUM BLIGHT

It is obvious that a knowledge of the origin of such a disease is of great importance in relation to many questions, such as the possibility of attack in any nursery, the effect on natural regeneration if it be native, and on the advisability of quarantine and embargo.

I have long been familiar with this disease on Balsam Fir, and have found it everywhere in the snow laden parts of Ontario and Quebec and in several of the northeastern States. But I was not so certain of its occurrence on native Spruce. In order to determine this matter I made journeys into the Spruce forests of Gaspé, Quebec, and Maine in September and November of 1928, and was rewarded by finding it in both places on White, Red, and to a lesser extent on Black Spruce, in regions where it was plainly native. A review of collections made previously and subsequently at various locations in the east, adds to the evidence that it is widely distributed on Spruce in eastern Canada and in the northeastern States. It is a safe conclusion that *Phacidium* blight of conifers is native to America. Under such circumstances the sane procedure is not to employ embargo or quarantine except in the case of wilfully neglected nurseries, but to be ever on the alert and to adopt control measures wherever it shows itself.

SUMMARY AND CONCLUSIONS

1. Phacidium blight of conifers is a disease favored by a covering of snow that persists throughout the winter. In Europe it (Schneeschütte) attacks *Pinus sylvestris* and is said to be caused by *Phacidium infestans*. In America various conifers are attacked; the Firs and various Spruces are especially susceptible; it is caused by a form or forms very similar to if not identical with *P. infestans*.

2. An extensive contagious spread takes place under the snow in late winter and early spring and there is none throughout the summer.

3. Any nursery or plantation in a snow laden area is liable to attack, and especially so if it be located in a forested district.

4. It is a disease that is potentially capable of rapid spread and great losses.

5. Being native there is more or less of a balance as between host and parasite under natural conditions. It is conceivable, however, that in many areas the natural regeneration of such a susceptible host as White Spruce may be seriously affected by it. So far no studies have been made on this point.

6. It has been found that it can be easily and cheaply controlled.

7. A reforestation planting policy in snow laden areas is liable to failure unless Phacidium blight be controlled.

Throughout the course of this investigation I have received generous support and invaluable co-operation from many quarters; due acknowledgments will be made in a detailed paper to be published in the near future.

THE LIGNEOUS FLORA OF THE DAVIS MOUNTAINS, TEXAS

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Far out towards the southwestern corner of the great state of Texas, but still some two hundred miles east of El Paso, the rugged peaks and ridges of the Davis Mountains rise rather abruptly from the surrounding high plains. Owing to the isolation of those outlying groups of the Rocky Mountains which occupy the generally arid region of western Texas they offer an extremely interesting field for the study of peculiar phases of the flora and fauna. And the Davis group, because of the higher altitude and the precipitous character of some of the mountains and other ecological factors to be mentioned later, seems to constitute one of the most distinct sub-regions biologically to be found in the state.

The Davis Mountains lie entirely within the limits of Jeff Davis County, a large area separated politically several years ago from Presidio County. The area of the county is 2263 square miles and the population according to the last census was only 1445. The number of inhabitants is somewhat, though not materially larger at present. Nearly half of the people live in the two principal towns of Ft. Davis and Valentine, the remainder be-



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