A. Hoen & Co. Baltimore.

CRONARTIUM RIBICOLA ON PINUS STROBUS AND RIBES.

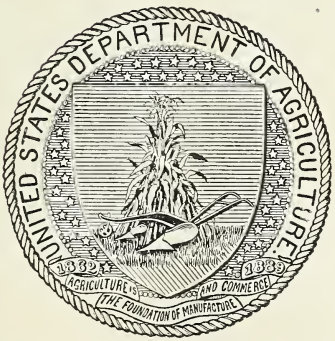
U. S. DEPARTMENT OF AGRICULTURE.
BUREAU OF PLANT INDUSTRY—BULLETIN NO. 206.
B. T. GALLOWAY, *Chief of Bureau.*

THE BLISTER RUST OF WHITE PINE.

BY

PERLEY SPAULDING,
Pathologist, Investigations in Forest Pathology.

ISSUED JULY 22, 1911.



WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1911.

BUREAU OF PLANT INDUSTRY.

Chief of Bureau, BEVERLY T. GALLOWAY.
Assistant Chief of Bureau, WILLIAM A. TAYLOR.
Editor, J. E. ROCKWELL.
Chief Clerk, JAMES E. JONES.

INVESTIGATIONS IN FOREST PATHOLOGY.

SCIENTIFIC STAFF.

Haven Metcalf, *Pathologist in Charge.*

George G. Hedgcock, *Pathologist in Charge of Forest Disease Survey.*
Perley Spaulding, *Pathologist in Charge of Forest Nursery Diseases.*
Carl Hartley, *Assistant Pathologist.*
Clarence J. Humphrey, *Assistant.*
Emile P. Meinecke, *Expert.*

LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Plant Industry,
Office of the Chief,
Washington, D. C., December 21, 1910.

Sir: I have the honor to transmit herewith a paper entitled "The Blister Rust of White Pine," by Dr. Perley Spaulding, Pathologist in the Office of Investigations in Forest Pathology, and recommend that it be published as Bulletin No. 206 of the special series of this Bureau.

This bulletin gives an account of a dangerous European disease of white pine, which also affects other five-needle pines and occurs on wild and cultivated currants and gooseberries. This disease has recently been widely introduced into America, but fortunately, by the prompt and active cooperation of all parties concerned, all cases found have been eradicated. But we have no evidence that all cases have been found, nor have we any means of preventing the importation of more diseased white-pine nursery stock. If this disease is not to become established in America, prompt action on all sides is necessary. It is therefore hoped that the recommendations of this bulletin will be generally carried out and that legislation may be enacted restricting further importations of diseased material.

The writer of this bulletin is indebted to the following persons for their cordial cooperation and aid in carrying on these investigations: The horticultural inspectors of New York, Pennsylvania, Ohio, and Indiana; the commissioners of agriculture and of forest, fish, and game in the State of New York; the State foresters of New York, New Jersey, Vermont, New Hampshire, Massachusetts, and Connecticut; the plant pathologists of Vermont, New York, Connecticut, Ohio, and Minnesota; the director of the Missouri Botanical Garden; Mr. George A. Chedel, and Drs. J. C. Arthur, W. G. Farlow, and Roland Thaxter.

Respectfully,

G. H. Powell,
Acting Chief of Bureau.

Hon. James Wilson,
Secretary of Agriculture.

CONTENTS.

ILLUSTRATIONS.

PLATES.

TEXT FIGURES.

B. P. I.—634.

THE BLISTER RUST OF WHITE PINE.

INTRODUCTION.

Within the past quarter century the science of forestry has become fairly well known throughout the country and is being practiced to a very encouraging extent. The advance in our knowledge and practice of forestry has resulted in the development of a general reforestation movement, especially in the North Central and Northeastern States. To be sure, replanting has been done in a small way for fifty years or longer (Kempton, 1903 [a]), but it is only within the past decade that interest in the work has become very general. During the last three years New York, Vermont, and Connecticut have aided the movement by furnishing stock to planters at cost prices. Reforesting in the States mentioned is concerned very largely with coniferous species and especially with white pine (*Pinus strobus* L.), which was formerly the most important forest tree of this section.

Naturally the increase in the demand for suitable small coniferous trees has led to the establishment of a number of forest-tree nurseries which supply this commercial demand. Of course there have been for years nurseries which supplied relatively small quantities of this stock; these met the demand for stock for ornamental purposes but not for practical field planting. During the past year or two American nurserymen have been unable wholly to supply the suddenly increased demand for planting stock, the entire available supply being sold in spite of the action of the Northeastern States in furnishing planting stock at cost prices.

American prices have been and still are considerably higher than European prices for the same grade of stock. This is partly due to the higher cost of manual labor in this country and partly to the inefficient methods and supervision given to this crop by many American nurserymen. There are many Americans who are fully competent to raise young fruit-tree stock and who are very successful in this branch of nursery work. But this class of stock is not usually seriously affected with the damping-off diseases, while the coniferous seedlings are as a class especially susceptible to them.

[a] For detailed information as to the works referred to in parentheses in this paper, see under "Bibliography," pages 61–78.

Certain species are nearly immune, but the larger number are seriously affected and many are very susceptible. Much of the damping-off in coniferous seedlings is caused by various species of Fusarium, fungi which are omnipresent in decaying organic matter both in the soil and on its surface. These diseases are dependent upon suitable weather conditions for their appearance in serious outbreaks in the seed beds, and they are very difficult to control when once they make their appearance. The average American nurseryman is unable to give his undivided attention to his seed beds, which is exactly what they need at times if he is raising conifers. Often prompt action on his part will avert or largely prevent a serious outbreak of damping-off. Lack of experience is often the cause of very large losses, and the cost of the remaining seedlings is unduly increased because of these excessive losses.

In a number of foreign countries, notably Germany, France, and Holland, the practice of forestry for centuries has resulted in a steady demand for great numbers of forest-tree seedlings for reforestation purposes. This has led to the establishment of many nurseries which supply planting stock at very reasonable prices. In Europe, where reforestation is largely carried on by national, State, or municipal authorities, the foresters employed often raise their own seedlings in the locality where they are to be used, and in some cases they even distribute surplus stock to private individuals free (Fox, 1903) or at cost. It is apparently not uncommon, however, for the seedlings to be bought of commercial nurseries (Fox, 1903; Thaler, 1903). The output of these nurseries mounts well up in the hundreds of millions. This stock is usually fine and thrifty and sells at a relatively low price as compared with similar American stock.

As a result of these various conditions, a considerable import trade in forest-tree seedlings and transplants has developed. There are many American nurserymen who regularly import their 1-year-old coniferous seedlings rather than raise them themselves. It is no exaggeration to say that in the spring of 1909 probably ten million coniferous seedlings were imported into this country from various European nurseries. Of these, several millions were white pine (*Pinus strobus*), 1-year-old and 2-year-old seedlings and 3-year-old transplants. A considerable number were also imported of each of the following five-leaved species, which are very closely related to *Pinus strobus*:[a] *Pinus monticola* Douglas, *P. lambertiana* Douglas, *P. flexilis* James, *P. cembra* L., *P. excelsa* Wall., *P. peuce* Gris., *P. ayacahuite* Ehrenb., *P. koraiensis* Sieb. and Zucc., *P. parviflora* Sieb. and Zucc. These were usually imported by nurserymen who make a specialty of landscape gardening, and these species were used entirely

[a] Beissner, L. Handbuch der Nadelholzkunde, 1909, pp. 340–371. The second edition is used in naming the 5-leaved pines.

for ornamental planting, thus being much more widely distributed than would be the case if they were used for forest planting.

The importation of foreign plant material, whether of seeds, cuttings, or whole plants, is accompanied with constant danger of introducing insect or fungous pests. The danger of introducing fungous pests is rather slight with seeds, although the contrary is true of insects, but with plants or cuttings the danger of introducing both fungi and insects is considerable unless suitable precautionary measures are taken. Insects, with certain exceptions, such as the wood-borers, may be killed by fumigation, while most fungous diseases can be detected by a rigid examination by a competent mycologist. There are fungous diseases, however, which at certain stages can not be detected even by the most skilled mycologist, owing to their having a preliminary stage of incubation during which the disease is not externally visible. The smuts of grain and other plants are very good examples of this kind of diseases. These fungi infect the young seedling host when it emerges from the seed, and the mycelial threads grow in the tissues of the stem until the formation of seeds is begun. All of this time (two or more months) the fungus gives absolutely no external indication of its presence. When the seed begins to form, the fungus commences to form its fruits within the seed and then becomes visible externally for the first time. The white-pine blister rust caused by *Cronartium ribicola* is one of this type of diseases, but has an incubation period of one to four years instead of a few months, as in the case of the smuts.

White-pine seedlings and transplants have been imported in relatively small numbers for years, and it is rather remarkable that the blister rust of white pine was not imported in quantity before 1909, when the Peridermium stage was first discovered in America. Mycologists and plant pathologists have been on the lookout for it for some time, and it could hardly have been previously imported to any extent without discovery. A few American foresters have refused to accept foreign white-pine seedlings and transplants because of their fear of this disease. These men were familiar with European conditions and thoroughly appreciated the danger of importing the fungus.

The white-pine blister rust now imported into this country from Germany is caused by a heterœcious fungus requiring two distinct kinds of hosts for its complete development. It lives in the one stage in the bark of white pines (Pl. I, *A;* Pl. II, figs. 1 and 2; text figs. 3, 4, and 5) and in the other stage in the leaves of wild and cultivated currants and gooseberries, known by the scientific name Ribes (Pl. I, *B, C, D*). The first stage fruits in the spring and summer, from early April to early June, while the latter stage fruits from about June 1 until the leaves of the Ribes fall.

HISTORICAL ACCOUNT OF CRONARTIUM RIBICOLA.

H. A. Dietrich, in 1856, in an annotated list of the fungi of the Baltic provinces of Russia, mentions *Cronartium ribicola*. About one or two years previously Dietrich apparently distributed in a set of dried plants entitled "Plantarum Florae Balticae Cryptogamarum" specimens of this fungus under the same name. This seems to have been the first time the name *Cronartium ribicola* was used. The writer has been unable to refer to the original specimens because he can not find anywhere in the country a set of these exsiccatæ. Nearly all European writers have attributed the name to Dietrich. This name was at first used only in connection with the fungus upon the leaves of Ribes, which was considered to be a distinct species. In 1887 Klebahn separated the species *Peridermium pini* (Willd.) Kleb., forma *corticola*, into three distinct species—*Peridermium pini*, *P. cornui* Rostr. and Kleb., and *P. strobi* Kleb. The third had *Pinus strobus* for its host, while the two others had other species of pine for their hosts. The Peridermium had previously been known on white pine in Europe, but had been included in the old composite species *P. pini*. In 1888 Klebahn proved that *Peridermium strobi* is but a stage in the life history of *Cronartium ribicola* by successfully inoculating Ribes leaves with spores of the former from white pine and obtaining upon the leaves of Ribes the characteristic spores of the latter.

These experiments were later repeated by Klebahn, as well as by a number of other investigators, viz, Von Wettstein (1890), Rostrup (1895), Schøyen (1895), Eriksson (1896 *a*), Von Tubeuf (1901 *a*), Hennings (1902 *a*), Sorauer (1891), and Jaczewski (1905, 1906, 1908). The following table shows the various species of Ribes upon which successful inoculations have been made with æcidiospores from *Pinus strobus*, including the writer's own experiments here cited for the first time.

Successful inoculations on Ribes with spores of Peridermium strobi from Pinus strobus.

Ribes.

1. Subgenus Siphocalyx:
   aureum Pursh.—Klebahn (1890 *b*, 1892 *a*), Sorauer (vide Klebahn, 1904 *a*), Von Tubeuf (1901 *a*), Spaulding.
2. Subgenus Ribesia:
   nigrum L.—Hennings (1902 *a*), Klebahn (1888 *b*, 1890 *b*, 1892 *a*, 1897 *b*), Eriksson (1896 *a*), Jaczewski (1905, 1906, 1908), Schøyen (1895), Sorauer (1891), Von Tubeuf (1901 *a*).
   sanguineum Pursh.—Sorauer (vide Klebahn 1904), Von Tubeuf (1901 *a*).
   americanum Mill.—Sorauer (vide Klebahn (1904), Spaulding.
   alpinum L.—Klebahn (1890 *b*, 1892 *a*), Sorauer (1891).
   rubrum L.—Klebahn (1890 *b*, 1892 *a*), Sorauer (1891), Schøyen (1895), Von Tubeuf (1901 *a*), Spaulding.
   multiflorum Kit.—Rostrup (1895).

Ribes—Continued.

3. Subgenus Grossularia:

Cynosbati L.—Von Tubeuf (1901 *a*), Spaulding.
setosum Lindley.—Sorauer (vide Klebahn, 1904).
oxyacanthoides L.—Von Tubeuf (1901 *a*).
gracile Michx.—Rostrup (1895).
divaricatum Douglas.—Von Tubeuf (1901), Rostrup (1895).
rotundifolium Michx.—Sorauer (vide Klebahn, 1904).
grossularia L.—Klebahn (1895 *a*), Schøyen (1895), Von Tubeuf (1901), Spaulding.

Tranzschel (vide Magnus, 1902) inoculated *Ribes nigrum* successfully with æcidiospores from *Pinus cembra* in 1894, thus showing that the fungus on this pine is identical with that on *Pinus strobus*. Neger (1908) found that *Ribes sanguineum* which he had previously set out near trees of *Pinus monticola* that were diseased with Peridermium became abundantly rusted with *Cronartium ribicola*. This proved the identity of the Peridermium upon the three species of pine, all being forms of *Cronartium ribicola* (fig. 2). Klebahn (1887) cites the occurrence of what is apparently the same species of Peridermium upon a single tree of *Pinus lambertiana* and later (1890 *b*) he was successful in inoculating Ribes with spores from this species. The Peridermium upon all four species of pine has the same morphological characters, and there is little doubt that they are identical. Rostrup (1902) states that he found *Pinus excelsa* diseased with Peridermium, but he does not state that it is *P. strobi*. The infection of pine with pycnospores from pine has been attempted by Klebahn (1889, 1904 *a*). He inoculated young *Pinus strobus* with pycnospores from the same species and obtained one or two apparent infections, but finally concluded that his experimental trees were already infected before he began his experiment. He later (1899) repeated the experiment with no results. Klebahn (1904 *a*) also tried inoculating *Pinus strobus* with æcidiospores from the same host, but without result. Tests made with teleutospores by Klebahn (1905 *a*) upon young *Pinus strobus* trees were successful, however. Ten months after the inoculations were made, the twigs showed swellings and had their needles of the juvenile form; later the usual form of needle was produced. The twig growth was short and the old needles were spotted and yellowish in color. Spermogonia were produced within one year from the time of the inoculation. Various tests have also been made by Klebahn (1908, 1897 *b*) with the spores of *Peridermium pini* upon Ribes and with spores of *P. strobi* upon the alternate hosts of *P. pini* with no results, thus proving them to be distinct.

DISTRIBUTION OF CRONARTIUM RIBICOLA.

CRONARTIUM RIBICOLA IN THE OLD WORLD.

Cronartium ribicola in one or both of its forms has been collected in and reported from the countries of the Old World as follows:

NORWAY. Schøyen (1895, 1896, 1897, 1901, 1903), Blytt (1896).

SWEDEN.

Stockholm: Eriksson (1890, Fung. Paras. Scand., Nos. 211, 280, 282), Ludwig (1892).
Upland: Eriksson (1896 *a*, 1896 *b*).
Vestergotland: Norstedt (N. Y. [a]).
Westmanland: Nilsson (1893), Romell (Fung. Exsicc. Scand., Nos. 150, 151).

DENMARK. Oersted (vide Magnus, 1873 *b*), Rostrup (vide Magnus, 1874 *a*), Lind (P. C.[b]), Von Thümen (Myco. Univ., No. 146).

RUSSIA.

Baltic Provinces: Dietrich (1856).
Esthonia: Gobi and Tranzschel (1891).
Finland: Hisinger (1876), Karsten (vide Von Thümen, 1880 *b*), Gobi and Tranzschel (1891).
Kazan: Sorokin (vide Körnicke, 1877).
Kursk: Jaczewski (1904, 1906), Bondarzev (1906, vide Jaczewski, 1904).
Kursk and Charkow: Potebnia (1907).
Livonia: Bondarzev and Bucholtz (1903), Jaczewski (1904, 1908).
Moscow: Stephankowo (vide Sorokin, 1876 *a*), Hennings (1903), Rabenhorst (Fung. Europ., No. 2381).
Novgorod: Jaczewski, Komarov, and Tranzschel (Fung. Ross. Exsicc., No. 68).
Orlov: Jaczewski (1906, 1908).
Poland: Jaczewski (1904).
St. Petersburg: Regel (vide Sorokin, 1876 *a*), Woronin (vide Sorokin, 1876 *a*), Gobi and Tranzschel (1891), Iwanoff (1900), Tranzschel (vide Magnus, 1902), Jaczewski (1904, 1908).
Tiflis: Speschneff (1899).
Tula: Nawaschin (vide Schellenberg, 1904), Jaczewski (1906).
Ural Mountains: Schell (vide Sorokin 1876 *a*), Sorokin (1876 *a*).
Voronej: Jaczewski (1908).

SIBERIA.

Inja River: Von Thümen (1880 *a*, Myco. Univers., No. 2049).
Minussinsk: Roumeguère (Fung. Sel. Exsicc., No. 4518).
Tomsk: Jaczewski (1904).

AUSTRIA-HUNGARY.

Bohemia: Bubák (1897, 1908), Kornauth (1904, 1907), Migula (Krypt. Germ., etc., No. 57).
Salzburg: Fritsch (In Fl. Exsicc. Austr.-Hung., No. 2367).
Tyrol: Kornauth (1907).

ITALY.

Lombardy: Turconi (1908).

---

[a] The abbreviation "N. Y." when used in this list indicates that a specimen is in the herbarium of the New York Botanical Garden.

[b] The abbreviation "P. C." when used in this list indicates that a specimen is in the pathological collections of the Bureau of Plant Industry, U. S. Dept. of Agriculture.

Switzerland. Fischer (1898 *a*, 1898 *b*, 1900, 1904), Schellenberg (1904), Rikli (1909), Krieger (Fung. Saxon., No. 767).

German Empire.

Alsace: Schüle (1904, 1905).

Baden: Von Tubeuf (1898 *a*), Oppenau (1905).

Bavaria: Von Tubeuf (1897 *a*, 1898 *a*), Weiss (1901, 1904).

Brandenburg: Magnus (1873 *b*, 1891 *a*, 1902), Hartig (vide Von Thümen, 1880 *b*), Sorauer (1893, 1902), Jaap (1900, 1904), Hennings (1902 *a*), Appel (1906), Sydow (Myco. March., Nos. 832, 1117, 1524, 1631, 1632, 2753, 2754, 2755, 2756, 2757, 2758, 3031, 3449, 3450, 3451, 3452, 3453, 3454, 3716, 3717).

Bremen: Klebahn (1887, 1888 *b*), Frank and Sorauer (1893), Von Tubeuf (1898 *a*), Rabenhorst-Winter (Fung. Europ., No. 3705 *a*), Sydow (Uredineen, No. 291).

East Prussia: Körnicke (1877).

Hamburg: Smith (1898), Von Tubeuf (1898 *a*), Klebahn (1902), Brick (1902, 1904).

Hanover: Klebahn (1887), Klugkist (1909).

Hesse: Thaler (1903), Lüstner (1905).

Lubeck: Brick (1901, 1902).

Mecklenburg: Sorauer (1899), Jaap (1905).

Oldenburg: Klebahn (1887, 1888 *b*, 1902), Brick (1901, 1902, 1904), Reh (1901, 1902).

Pomerania: Fischer von Waldheim (1872), Hartig (1874), Ewert (1903), Rabenhorst (Fung. Europ., No. 1595), Sydow (Uredineen, No. 1091).

Saxony: Staritz (1903), Endler (1904), Neger (1906, 1908), Krieger (Fung. Saxon. No. 767, 1417).

Schleswig-Holstein: Magnus (1873 *a*), Fischer (vide Von Tubeuf 1897 *a*), Smith (1898), Klebahn (1902, 1904 *b*), Pettis (1909, 1910), Von Reitzenstein (1909), Spaulding (1909 *a*, 1909 *b*, 1910 *a*, 1910 *b*).

Silesia: Schroeter (1889), Lauche (vide Magnus, 1891 *a*), Frank (1897), Aderhold (1901), Ewert (1904), Sydow (Myco. March., No. 3267).

Thuringia: Köhler (1909), Hennings (N. Y.), Bornmüller (Krypt. Exsicc. Vindobonensis, No. 1131).

Westphalia: Smith (1898), Von Tubeuf (1898 *a*), Sorauer (1901), Spieckermann (1905).

West Prussia and Posen: Schander (1910).

Wurtemberg: Kirchner (1902).

France.

Ardennes: Pechon (1907).

Meurthe-et-Moselle: Destrée (N. Y.).

Orne: Lemée (P. C.).

Paris: Griffon and Maublanc (1909).

Pas-de-Calais: Géneau de Lemarlière (P. C.).

Seine-et-Marne: Briosi and Cavara (Fung. Paras. Colt., No. 255).

Vosges: Hariot (vide Griffon and Maublanc, 1909).

Belgium. Vanderyst (1899, 1900 *a*, 1900 *b*), Nypels (1900), Marchal (1901, 1902, 1903, 1905, 1907).

Holland. Oudemans (1892), Ritzema Bos (1901), Destrée (P. C.).

England. Plowright (1892 *a*, 1892 *b*, 1893, 1898–99), Smith (1898), Rea (1902), Somerville (1909).

Scotland. Laurie (1898), Somerville (1909).

Japan. Takahashi (1906).

The known distribution in Europe covers practically all those countries which are well known mycologically. Besides, *Cronartium*

ribicola is known from several localities in western Siberia and Japan. It can be safely stated that it occurs practically throughout Europe except in the Balkan and Hispanic peninsulas (fig. 1). It is especially abundant in Germany, Denmark, Belgium, and Holland, but when we remember that in these countries the mycological flora is best known it becomes evident that the fungus is exceedingly prevalent throughout Europe. It is apparently most common in those countries where forestry is practiced most; in these countries there are many forest-tree nurseries and consequently greater chance for

FIG. 1.—Outline map of Europe, showing the localities where *Cronartium ribicola* has been found.

the fungus to spread naturally and to be distributed in infected young pine trees.

CRONARTIUM RIBICOLA IN AMERICA.

Although the fungus *Cronartium ribicola* has been definitely known in America but a short time, namely, since 1906, when the Cronartium stage was first recognized by Stewart (1906), it has become widely distributed. Its first known occurrence was in Kansas in 1892, when the uredo stage was collected on *Ribes aureum*, but was not recognized until some years later. It was at the time erroneously named *Uredo confluens* Pers., but has since been identified as

Cronartium ribicola (Arthur, 1907). There is absolutely no explanation of this isolated occurrence in the middle of the American Continent. The fungus has not been found since in the same locality or anywhere in America until 1906, and there are and have been no white pines in the Kansas locality so far as is known. The uredo and teleuto stages were found by Stewart (1906) at Geneva, N. Y., on the leaves of various species of Ribes at the State experiment station. The entire Ribes plantation was pulled up and burned, and the disease apparently was successfully eradicated. In the spring of 1909 it was discovered that the æcidial stage, formerly known as *Peridermium strobi*, had been imported on several millions of young white pines from the nursery of J. Heins Söhne, of Halstenbek, Germany. Investigations to date show that the fungus has thus far been found in Kansas, New York, Pennsylvania, Vermont, New Hampshire, Massachusetts, Connecticut, Ohio, Indiana, and possibly is present in Minnesota, and in Ontario, Canada. Lots of trees from J. Heins Söhne have been distributed to 226 localities in America. The imported trees were very uniformly affected, and practically every lot of 5,000 or more of the 3-year-old white pines from J. Heins Söhne examined by the writer was found to have a number of diseased trees.

Diseased trees have been found in 1910 which were obtained of the following French firms: Levavasseur & Fils, Ussy; Barbier & Co., Orleans; and E. T. Dickinson, Chatenay.

In the late autumn of 1909 Mr. Stewart H. Burnham found *Cronartium ribicola* on *Ribes rubrum* in the vicinity of West Fort Ann, N. Y. The fungus was not identified by Mr. Burnham until the spring of 1910, when a very careful search failed to reveal the fungus on white pine or on the Ribes in the vicinity. The nearest known plantation of imported white-pine trees is 2 miles distant. It seems hardly likely that spores were carried this distance by the wind, but this is apparently the only explanation of the occurrence of the fungus there.

ECONOMIC IMPORTANCE OF THE BLISTER RUST.

BLISTER RUST ON RIBES.

The Cronartium stage on various species of currants and gooseberries is usually the most abundant and conspicuous in its effects, but the actual damage caused is not great. The rust attacks the under side of the leaves. In the uredo form the fruiting bodies are grouped in small rounded areas 1 to 5 millimeters ($\frac{1}{16}$ to $\frac{3}{8}$ inch) across, and the mycelium seems to extend but little beyond the bounds of these areas, thus involving only slightly the leaf tissues. When the attack is light, so that the pustules are scattered, the leaf is but little

affected. When the attack is intense the pustules become crowded thickly together, and a considerable proportion of the leaf tissue is affected; this leads to the premature death of the leaf and its fall from the plant, the earliness of this depending upon the season of the attack and its intensity. Badly diseased bushes thus become prematurely defoliated, and are weakened to a greater or less extent. They apparently usually survive, however, there being few statements to the contrary (Jaczewski, 1904, 1905, 1906, 1908). This is probably due to the fact that the disease is not known to live over winter on Ribes, and thus continue its attacks from year to year with increasing severity. There are cases, however, which apparently can be explained in no other way than by the fungus living over winter on the youngest wood of the Ribes bushes (Stewart, 1906, and Nilsson, 1893) or else on dead leaves which remain all winter on the bushes, but such persistence has not been demonstrated.[a] The worst features of the Cronartium stage are that it apparently is not limited to a few species of Ribes, but may attack all of the numerous species more or less indiscriminately, and is thus a most efficient means of distributing the fungus to the pines, where the real damage is done.

BLISTER RUST ON PINES.

The Peridermium stage is the one in which the chief damage is done. The fungus lives year after year in the bark of the pine, extending its field of action until the stem or branch is girdled and the tree or branch above the swelling dies outright. The fungus is sure to kill its host tree if the attack is on the stem, since even if the tree survives until it is twenty-five or thirty years old it becomes relatively weak at the place of attack, and finally breaks over in some heavy wind (Pechon, 1907). Most of the young trees which are attacked on the stem die the first season that the fungus forms æcidiospores. Yet a considerable number survive, and a constantly decreasing number is left each year. Upon such remnants of the original diseased stock the fungus fruits each succeeding year, thus obtaining multiplied chances for perpetuating itself upon any Ribes bushes that may be in the vicinity. Far the greatest damage is caused by the dying of young trees in nurseries, plantations, and young reproduction growths. The fungus occurs on older trees quite often, however, but attacks only the younger branches and twigs. Where the attacks are severe, old trees may be entirely killed, but such cases are apparently exceptional. The fungus seems to be unable to infect the bark which is more than twenty years old (Hess, 1900). The great uncertainty

[a] The writer has found the æcidial stage of *Puccinia albiperidia* Arthur, which commonly attacks only the leaf blades of Ribes, upon the petioles and occasionally even upon the young twigs of *Ribes prostratum*.

caused by the fungus incubating for one or more years before showing evidence of disease makes it especially difficult to eliminate from an infected lot of trees.

This disease is essentially a disease of young trees, and especially of nursery stock. In Europe the total cumulative loss has reached 100 per cent in some instances, and there are numerous cases where it was one-third the total number or more. Instances have been found where the cultivation of *Pinus strobus* had to be discontinued because of this disease. (Klebahn, 1889; Ritzema Bos, 1901; and Smith, 1898.) The most common way for the Peridermium stage of the fungus to be distributed is in infected nursery stock, it often being sent thousands of miles in this manner. (Thaler, 1903; Weiss, 1899; Von Tubeuf, 1898*a;* Klebahn, 1904*a;* Smith, 1898; Pettis, 1909, 1910; and Spaulding, 1909 *a*, 1909 *b*, 1910 *a*, 1910 *b*.)

Many more or less definite statements have been found of the occurrence of this disease in European nurseries, but in most cases the nursery is not named. The following German nurseries are known to have had the disease upon pine or Ribes at approximately the dates indicated: J. Heins Söhne, Halstenbek (Holstein) in 1904–1910 (personal observations on trees imported from this firm); Späth, Berlin, in 1887–1895 (Sydow, specimens issued in his "Uredineen" and "Mycotheca Marchica"); H. C. A. Helleman, Moorende (near Lilienthal, Hanover) in 1886–7, (Klebahn, 1887); Metz & Co., Steglitz, near Berlin, in 1887–9 (Magnus, 1891 *a*); H. H. Pein, Halstenbek (Holstein), "several years ago" (Von Reitzenstein, 1909). There are a number of less definite statements indicating that the disease has occurred in nurseries at or near the following places: *Germany:* Berlin, Brandenburg (Sorauer, 1902); Muskau, Silesia (Magnus, 1891 *a*); Eberswalde, Brandenburg (Magnus, 1902); Amelsbüren, Westphalia (Spieckermann, 1905); Delmenhorst, Oldenburg (Klebahn, 1887); Tharandt, Saxony (Neger, 1908); Hamburg (Smith, 1898); Mühlenbeck (Von Tubeuf, 1897 *a*). *France:* Paris (Griffon and Maublanc, 1909). *Sweden:* Stockholm (Eriksson, 1890). *Russia:* St. Petersburg (Magnus, 1902).

Diseased trees have been shipped to America from three French firms already mentioned: Levavasseur & Fils, Ussy; Barbier & Co., Orleans; and E. T. Dickinson, Chatenay. It is not known whether the trees were grown by these firms.

In America the opportunity to obtain data on the damage caused by *Cronartium ribicola* has fortunately been very limited. In a large lot of imported 3-year-old pines an actual count showed that exactly 1 per cent were visibly diseased the first season that the fungus appeared. It is estimated that about 500 trees were destroyed in another lot of 50,000 of the same age, while in another case over 300

were destroyed out of 2,000, and probably many more should have been destroyed, as fully half of those set in the field have since died. Other lots have shown percentages of 0.2 to 3 of visibly diseased trees.

There are many definite statements of damage caused in various European countries, as follows:

Plowright (1892 *b*) first found the fungus in England in 1892. Smith (1898) says that reports of the disease are frequent upon *Pinus strobus*, and that the disease is being distributed from Germany, whence nursery stock is imported. He also states that it became so serious in a large nursery in Westphalia, near the Holland frontier, that the stock was destroyed and the use of this species was discontinued for a time; also that the disease is common in many nurseries around Hamburg, and that a supply of white pines from a nursery in Holstein and used near Lake Constance had to be removed and burned in less than two years.

Somerville (1909) says of the situation in England:

> This disease is so much on the increase that it is not too much to say that the outlook in this country for the Weymouth (white) and other five-leaved American pines is almost hopeless. * * * But it is to be feared that the day is not far distant when it will gain a footing in North America, and if it spreads there, as it has done in Europe, the loss that will result through the destruction of one of America's most valuable lumber trees can only be described as appalling. On the Weymouth and similar pines, on the other hand, it is so fatal that there are estates in Britain (e. g., Murthly in Perthshire and Woburn in Bedfordshire) where hardly a living example of *P. strobus* or *P. monticola* is left, at least of the younger classes.
>
> It is not pleasant to have to give this opinion, but anyone who has seen the condition of things on the estates mentioned or in the Crown woods near Windsor and Ascot must realize how hopeless is the future of the Weymouth pine in this country.

The fungus was first noted in Sweden in 1887, and has appeared every spring since. Eriksson (1890) says that at first it attacked only young trees, but in 1889 it also attacked quite large ones. Nordstedt (1888) found both stages in large quantities in Vestergotland.

In Denmark, Rostrup (1883) says that *Peridermium strobi* on *Pinus strobus* causes more damage than any other species of bark-inhabiting Peridermium.[a]

In Finland, Hisinger (1876) found 30-year-old trees of *Pinus strobus* diseased and finally killed by *Peridermium strobi* upon their stems. Dietrich (1856) says that affected trees of *Pinus strobus* seen by him in the Baltic Provinces of Russia were mostly killed in a few years. Tranzschel (vide Magnus, 1902) found young plants of *Pinus cembra* in the nursery of the St. Petersburg Royal Forestry Institute so seriously attacked by this disease that entire beds were killed.

[a] While on a recent visit to this country, Prof. Dr. F. K. Ravn, of Copenhagen, Denmark, orally informed us that the white pine would be very successful in Denmark were it not for the attacks of this fungus. The blister rust, however, has caused the virtual abandonment of the use of this species in that country.

German writers have often mentioned the damage caused by this fungus. Brick (1901) says that the Peridermium stage occurs in the forests of Lübeck. Ewert (1903) found it very widespread in the protective planting of the Royal Pomeranian Institute, so that one tree after another became affected. Even old trees were not exempt. Hennings (1902 *a*) found the Cronartium stage abundant year after year about Berlin. Hess (1900) says that the disease is very destructive to white pine, the stem and branches above the thickened part dying as a rule. He also says the stems of 20 to 25 years or older seem not to become diseased. Klebahn (1887, 1888 *b*) found approximately 30 per cent of all the white pine trees in the Bremen city park affected by *Peridermium strobi*. Of the diseased trees about 47 per cent were attacked on the stem. The affected trees were partly scattered and partly in patches. The large trees were usually attacked only on the branches. A single tree of *Pinus lambertiana* was found diseased also, while trees of *P. silvestris*, *P. nigricans*, *P. cembra*, and *P. mughus* were not affected. He mentions an instance where an entire lot of 1,000 4-year-old white pine trees were destroyed by *Peridermium strobi*. The disease occurred in the nursery of H. C. A. Helleman, at Moorende, near Lilienthal, and affected 16 per cent of the white pine trees. He noted it near Delmenhorst in considerable quantity and received specimens from Schwarze Berge in Hanover. He also says that this species is earlier than other native Peridermia, fruiting from April 25 to June 10. Köck (1908 *b*) speaks of it as a "very injurious disease." Köhler (1909) found that the larger part of the white pines in the Altenburg park were dying from attacks of this fungus. He also says its eradication is difficult and laborious. Magnus (1891 *a*, 1891 *b*, 1902) says that both forms occur destructively, as he has repeatedly observed. He also especially mentions its occurrence very abundantly on Ribes in the nursery of Metz & Co., at Steglitz, near Berlin, and on white pine in nurseries at Muskau, where 800 young trees were destroyed. Magnus also noted the disease for several years in the nursery of the Royal Forest Academy at Eberswalde. Neger (1906, 1907, 1908) found some 18-year-old trees of *Pinus monticola* at the Royal Forest Academy at Tharandt affected with *Peridermium strobi*, and he mentions this as causing the most destructive disease of *Pinus strobus* in Europe. The blister rust is said by Von Reitzenstein (1909) to have caused discrimination against white-pine stock from Halstenbek several years ago. The diseased trees were burned and the fungus is said to be unknown there now. While this statement may be true for the nurseries of H. H. Pein, about which he was writing at the time, it is decidedly untrue of those of J. Heins Söhne, as is shown by the large numbers

of diseased trees shipped thence to America in 1908 and 1909.[a] Sorauer (1902) found young white pines seriously attacked by *Peridermium strobi* in a nursery near Berlin. Spieckermann (1905) mentions the occurrence of this disease in a nursery at Amelsbüren, where it killed numerous white-pine trees from 2 to 4 years old. Thaler (1903) says that in Hesse a number of head foresters reported *Peridermium strobi* occurring on stock bought of private nurseries. In one case the number of diseased trees was about 1 per cent of the whole. Thaler advises the buying of white-pine stock from private nurseries with caution. Von Tubeuf (1897 *a*, 1898 *a*, 1905 *a*) mentions a number of other fungi destructive to *Pinus strobus* in Europe, but says that *Peridermium strobi* is the most destructive of all, killing branches and whole stems. It is distributed on young trees and thus becomes scattered in places where it previously did not occur. In a forest of Westphalia he found many small trees diseased, and in one of the largest nurseries near the Holland boundary he found the culture of white pine was wholly given up because of this disease. He says it is widespread about Hamburg and is distributed thence in nursery stock. He also mentions finding it in a nursery at Mühlenbek and in a park at Bad Kohlgrub. It is constantly spreading and causing more damage, and is difficult to eradicate. Weiss (1899) says that epidemics of the disease may easily occur where Ribes and white pines are raised in the same nursery; also that owners of nurseries should take pains that only healthy stock be sent out, since the disease is very often spread by the sending out of plants which are already infected.

In Bohemia, Bubák (1908) states that the æcidia are formed from the middle of April to June. He also mentions the disease as killing young trees of *Pinus strobus* planted in the field.

Schellenberg (1904) found *Peridermium strobi* on *Pinus cembra* in Switzerland, probably in the same locality where Fischer found the Cronartium stage in 1895. In this case it attacked a 15-year-old branch of a tree 200 years old, and had evidently infected the branch 10 to 12 years previously. Schellenberg concludes that this shows that the fungus is endemic in the Alps.

Griffon and Maublanc (1909) found the disease on *Pinus strobus* plants 4 or 5 years old, in a large nursery in the suburbs of Paris. They also say that the fungus in 1908 caused great damage in the forest of Fontenoy. Pechon (1907) states that when pine plants of 2 to 8 years are seriously attacked they usually die, while older ones continue to sprout; but that when the affected tree lives to be about 35 years old the weight of the top becomes too much for

[a] Moreover, stock has been received from this firm in this country during the spring of 1911, which, when unpacked, bore fruiting bodies of the blister rust.

the weakened stem and a heavy wind breaks it over. He also says that older trees often become partly or entirely decrowned by the killing of the smaller branches and that the disease is common in Ardennes and should be vigorously combated. Marchal (1901) finds the fungus common in Belgium in both stages and states that the disease incubates for one year to several years. Nypels (1900) says that this disease has spread rapidly throughout Belgium in the last few years. Ritzema Bos (1901) states that the fungus is so prevalent in Holland that the culture of white pine is impossible.

HOSTS OF CRONARTIUM RIBICOLA.

THE NORTH AMERICAN AND FOREIGN SPECIES OF FIVE-LEAVED PINES.

The æcidial or Peridermium stage of *Cronartium ribicola* has been found only on species of pine belonging to the 5-leaved group. This is sometimes called the Strobus or white-pine group. Trees of *Pinus strobus* only have been found diseased in America. In Europe, trees of *Pinus cembra, P. strobus, P. monticola, P. lambertiana,* and *P. excelsa* have been found affected by this fungus. Apparently no inoculation experiments have been made with other species, so that our knowledge in this respect is deficient. The fungus is apparently native on *P. cembra,* but has attacked the three American and the single Asiatic species of the Strobus group which have been exposed to infections while no species of the other groups are affected, although they have been present in proximity to diseased *P. strobus.* There is every reason to believe that other species of the Strobus group may become hosts of this fungus under favorable circumstances.

The possible host species are as follows:

NORTH AMERICA.

	Name.	*Range.*
1.	*Pinus ayacahuite* Ehrenb	Southern Mexico into Guatemala.
2.	*Pinus strobiformis* Engelm.	Southern Arizona into Chihuahua, Mexico.
3.	*Pinus flexilis* James.	Rocky Mountain region.
4.	*Pinus albicaulis* Engelm.	British Columbia and Alberta to Montana, Wyoming, Washington, Oregon, and southern California.
5.	*Pinus balfouriana* Murray	California.
6.	*Pinus aristata* Engelm.	High peaks from Colorado to southern Utah, Nevada, southeastern California, and northern Arizona.
7.	*Pinus strobus* L.	Newfoundland to Pennsylvania, along the Appalachians to Georgia, west to eastern Iowa and Minnesota; in Canada from Lake Winnipeg to northern shore of St. Lawrence Gulf and Newfoundland.
8.	*Pinus monticola* Douglas.	Montana and southern British Columbia to Washington, Oregon, and California.
9.	*Pinus lambertiana* Douglas.	Oregon through California to Lower California and Mexico.

FOREIGN COUNTRIES.

	Name.	*Range.*
10.	*Pinus excelsa* Wall.	Himalaya Mountain region.
11.	*Pinus peuce* Gris.	Montenegro, Bulgaria, and Balkan Mountains.
12.	*Pinus scipioniformis* Mast.	Central China.
13.	*Pinus pentaphylla* Mayr.	Japan.
14.	*Pinus parviflora* Sieb. and Zucc.	Japan.
15.	*Pinus pumila* Rgl.	Northeastern Siberia and Japan.
16.	*Pinus koraiensis* Sieb. and Zucc.	Japan, Korea, Kamchatka, Manchuria, western China, and Formosa.
17.	*Pinus armandii* Franch.	China.
18.	*Pinus cembra* L.	In Alps, Carpathians, Urals, northern Russia, and Siberia.

A glance at the territory included within the combined ranges of these species shows that a large part of the entire north temperate region is covered. The disease is at present known to occur nearly throughout Europe, in the western part of Siberia, and now occurs in the Eastern States of this country, as well as in Ontario, Canada. So far as we know the fungus might be able to attack any or all of these species, and might become distributed in time to practically all parts of the north Temperate Zone.

The Cronartium stage, including both the uredo and teleuto forms, occurs only on the leaves of the various species of Ribes. A Cronartium has been reported (Tulasne, 1854) on Ribes in India, but it is uncertain whether it is *C. ribicola*. Records have been found showing the occurrence of this fungus on about twenty-five distinct species of Ribes, besides numerous horticultural and botanical varieties or subspecies. The accompanying diagram (fig. 2)[a] shows the transfer of the fungus from the three species of pine to the various species of Ribes, so far as this is definitely known.

KNOWN HOST SPECIES OF RIBES.

Cronartium ribicola has been collected and reported as occurring on the following species of Ribes:[b]

[a] (1) Hennings, 1902 *b;* (2) Fischer, 1904, for *Pinus cembra;* Hennings, 1902 *b* for *Pinus strobus;* (3) Ewert, 1903; Hennings, 1902 *b;* (4) Jaap, 1905, for *Pinus cembra;* Blytt, 1896, Bubák, 1908, Ewert, 1903, Hennings, 1902 *b*, for *Pinus strobus;* (5) Hennings, 1902 *b;* (6) Hennings, 1902 *b;* (7) Hennings, 1902 *b;* (8) Ewert, 1903, Hennings, 1902 *b*, Rostrup, 1902; (9) Bubák, 1908, Ewert, 1903, Hennings, 1902 *b;* (10) Hennings, 1902 *b*, Rostrup, 1902; (11) Bubák, 1908, Hennings, 1902 *b;* (12) Hennings, 1902 *b*, Rostrup, 1902; (13) Iwanoff, 1900, Jaap, 1900, 1904, Magnus, 1902, for *Pinus cembra;* Blytt, 1896, Bubák, 1908, Ewert, 1903, Hennings, 1902 *b*, Jaap, 1905, Klebahn, 1902, Magnus, 1902, for *Pinus strobus;* (14) Hennings, 1902 *b;* (15) Fischer, 1898, 1904, for *Pinus cembra;* Hennings, 1902 *a*, for *Pinus strobus;* (16) Hennings, 1902 *b;* (17) Hennings, 1902 *b;* (18) Jaap, 1900, for *Pinus cembra;* Bubák, 1908, Hennings, 1902 *b*, for *Pinus strobus;* (19) Bubák, 1908, Ewert, 1908, Hennings, 1902 *b*, for *Pinus strobus;* Neger, 1908, for *Pinus monticola;* (20) Hennings, 1902 *b;* (21) Hennings, 1902 *b*.

[b] The Index Kewensis is followed in naming the Ribes.

aciculare Sm. Hennings (1902 *a*); Klebahn (1904 *a*).
alpinum L. Fischer (1904); Klebahn (1890 *b*, 1892 *a*); Sorauer (1891); Staritz (1903); Von Tubeuf (1901 *a*); Sydow (Uredineen, No. 381); Sydow (Myc. March., No. 1631).
americanum Mill. Ewert (1903); Hennings (1902 *a*); Klebahn (1904 *a*); Magnus (1902); Sorauer (1891); Von Tubeuf (1901 *a*).
aureum Pursh. Arthur (1907); Bartholomew (1899); Blytt (1896); Brick (1902); Bubák (1897, 1908); Ewert (1903); Fischer von Waldheim (1872); Frank and Sorauer (1893); Gobi and Tranzschel (1891); Hennings (1902 *a*, 1902 *b*); Jaap (1905); Klebahn (1890 *b*, 1892 *a*); Magnus (1873 *a*); Sorauer (1891); Sorokin (1876 *b*); Stewart (1906); Von Tubeuf (1901 *a*); Winter (1880); Sydow (Myc. March., No. 832); Sydow (Uredineen, No. 89, 1090); Eriksson (Fung. Paras. Scand., No. 280); Rabenhorst-Winter (Fung. Europe, No. 3705 *b*); Migula (Krypt. Germ., etc., No. 57); Krieger (Fung. Saxon., No. 1417); Krieger (Schadl. Pilze, No. 115); Klebahn and Magnus (P. C.).

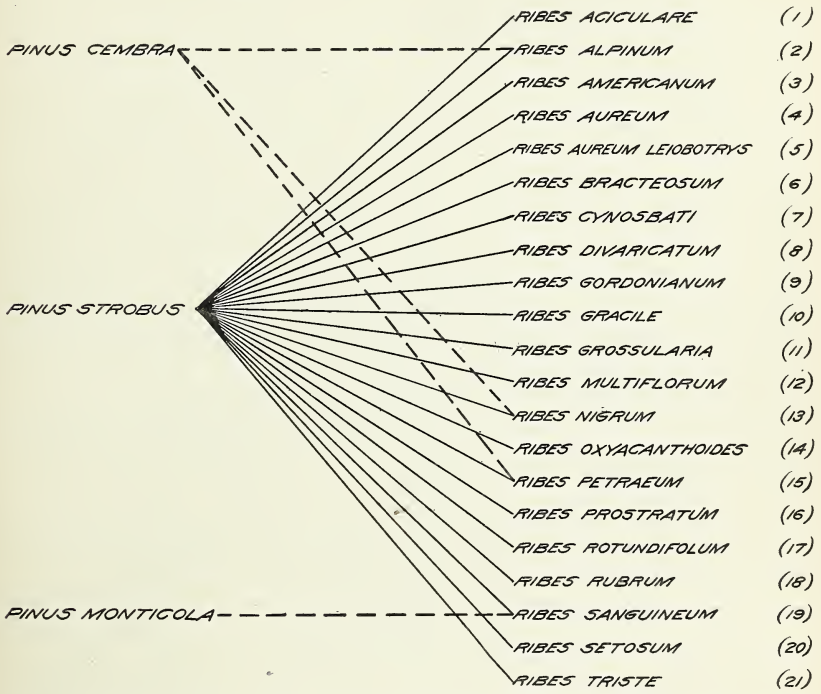


FIG. 2.—Diagram showing transfers of *Cronartium ribicola* from the pines to various species of Ribes The numbers in parentheses refer to the authorities cited in the footnote on p. 22.

aureum var. *leiobtrys* Zabel. Hennings (1902 *a*); Klebahn (1904 *a*).
aureum var. *palmatum* Desf. Dietrich (1856); Gobi and Tranzschel (1891).
bracteosum Douglas. Hennings (1902 *a*); Klebahn (1904 *a*).
cynosbati L. Hennings (1902 *a*); Von Tubeuf (1901 *a*); Vestergren (Micro. Rar. Sel., no. 476); Rabenhorst-Pazsche (Fung. Europ. and Extra, No. 4311).
divaricatum Douglas. Ewert (1903); Hennings (1902 *a*); Rostrup (1895); Von Tubeuf (1901 *a*).
gordonianum Lem. Bubák (1908); Ewert (1903); Hennings (1902 *a*); Klebahn (1904 *a*); Rabenhorst-Pazsche (Fung. Europ. and Extra., No. 4312).

gracile Michx. Klebahn (1904 *a*); Rostrup (1895); Sydow (Myc. March., No. 3716); Sydow (Uredineen, No. 592).

grossularia L. Brick (1902); Bubák (1908); Hennings (1902 *a*); Klebahn (1895 *a*); Poirault (1890); Speschneff (1899); Stewart (1906); Sydow (Myc. March., No. 1632); Krieger (Fung. Saxon., No. 1907).

grossularia var. *arboreum* Hort. Sydow (Uredineen, No. 383).

heterophyllum Phil. Hennings (1902 *a*); Klebahn (1904 *a*); Rabenhorst-Pazsche (Fung. Europ. and Extra., No. 4111); Sydow (Uredineen, No. 591); Sydow (Myc. March., No. 3452); Vestergren (Micro. Rar. Sel., No. 476).

intermedium Tausch. Sydow (Uredineen, No. 241); Sydow (Myc. March., No. 2757).

macrobotrys Ruiz. and Pav. Sydow (Uredineen, No. 594); Sydow (Myc. March., No. 3451).

menziesii Pursh. Sydow (Uredineen, No. 983).

multiflorum Kit. Hennings (1902 *a*); Klebahn (1904 *a*); Rostrup (1895).

nigrum L. Rostrup (1874); Blytt (1896); Bondarzev (1906); Bondarzev and Bucholtz (1903); Brick (1902); Bubák (1908); Deitrich (1856); Eriksson (1896); Ewert (1903); Frank and Sorauer (1893); Hennings (1902 *a*); Iwanoff (1900); Jaap (1900, 1904, 1905); Jaczewski (1904, 1905, 1906, 1908); Kirchner (1902); Klebahn (1888 *b*, 1890 *b*, 1892 *a*, 1897 *b*, 1902, 1904 *b*, 1905 *b*); Körnicke (1877); Magnus (1874 *a*, 1902); Marchal (1901); Nilsson (1893); Oudemans (1892); Poirault (1890); Potebnia (1907); Schroeter (1889); Sorauer (1891, 1901); Sorokin (1876 *a*); Stewart (1906); Von Tubeuf (1901 *a*); Vanderyst (1899); Weiss (1901); Winter (1880); Bartholomew (Fung. Columb., No. 2318); Eriksson (Fung. Paras. Scand., No. 211); Jaczewski, Komarov, and Tranzschel (Fung. Ross. Exsicc., No. 68); Krieger (Schadl. Pilz., No. 72); Krieger (Fung. Saxon., No. 615); Géneau de Lemarlière, Lemée and Magnus (P. C.); Migula (Krypt. Germ., etc., No. 57); Möller (P. C.); Nordstedt (N. Y.); Rabenhorst (Fung. Europ., No. 2381); Romell (Fung. Exsicc. Scand., Nos. 150, 151); Rostrup (specimen in Cryptogamic Herb., Harvard Univ.); Stewart (P. C.); Sydow (Myc. Germ., No. 159); Sydow (Uredineen, No. 41, 1091); Sydow (Myc. March., No. 1117); Von Thümen (Myc. Univ., No. 146).

nigrum var. *aconitifolium* Hort. Gobi and Tranzschel (1891); Sydow (Uredineen, No. 382).

nigrum var. *crispum* Hort. Sorauer (1891).

nigrum var. *laciniatum* Hook. Sorauer (1891).

orientale Desf. Sydow (Myc. March., Nos. 3717, 2753).

oxyacanthoides L. Hennings (1902 *a*); Von Tubeuf (1901 *a*); Rabenhorst-Pazsche (Fung. Europ. and Extra., No. 4111); Sydow (Myc. March., No. 2755).

parvifolia Phil. Sydow (Myc. March., No. 2758).

petraeum Wulf. Fischer (1898 *a*, 1900, 1904); Hennings (1902 *a*); Klebahn (1904 *a*).

prostratum L'Herit. Hennings (1902 *a*); Klebahn (1904 *a*).

rotundifolium Michx. Hennings (1902 *a*); Sorauer (1891); Von Tubeuf (1901 *a*); Sydow (Myc. March., No. 3453); Sydow (Uredineen, No. 597).

rubrum Linn. Arthur (1907); Bondarzev (1906); Bubák (1897, 1908); Dietrich (1856); Gobi and Tranzschel (1891); Hennings (1902 *a*); Jaap (1900); Jaczewski (1908); Kirchner (1902); Klebahn (1890 *b*, 1892); Oudemans (1892); Poirault (1890); Sorauer (1891); Speschneff (1899); Staritz (1903); Stewart (1906); Von Thümen (1880 *a*); Turconi (1908); Winter (1880); Bornmuller (Krypt. Exsicc. Vindobonensis, No. 1131); Destrée (P. C. and N. Y.); Fritsch (Fl. Exsicc. Aust.-Hung., No. 2367); Hennings (N. Y.); Krieger (Fung. Saxon., No. 1555); Roumeguère (Fung. Sel. Exsicc., No. 4518); Sydow (Uredineen, No. 845); Sydow (Myc. March., No. 1524); Von Thümen (Myc. Univ., No. 2049).

sanguineum Pursh. Bubák (1908); Ewert (1903); Hennings (1902 *a*); Neger (1908); Sorauer (1891); Von Tubeuf (1901 *a*); Krieger (Fung. Saxon., No. 2010); Lind (P. C.); Sydow (Myc. March., No. 1633.)
saxatile Pall. Sydow (Myc. March., No. 3031).
setosum Lindl. Hennings (1902 *a*); Sorauer (1891); Von Tubeuf (1901 *a*); Sydow (Uredineen, No. 599, 593); Sydow (Myc. March., No. 3454).
triste Pall. Hennings (1902 *a*); Klebahn (1904 *a*).

Of the twenty-six species here given, thirteen are American species. These in their wild state include the larger part of North America within their ranges. But those regions in which the wild species do not occur are well supplied with cultivated ones. One can scarcely doubt that *Cronartium ribicola* in time would spread throughout the continent should it once become well established in any one State.

At various times different investigators (Schroeter, 1875; Sorokin, 1876 *b;* Sorauer, 1891; Klebahn, 1892 *a*, 1893 *a*, 1895 *a;* Brick, 1902; Hennings, 1902 *a;* Ewert, 1903, 1904; Appel, 1906; Neger, 1908) have noted the apparent immunity of certain species of Ribes to the disease. Such species are *Ribes grossularia*, *R. sanguineum*, *R. alpinum*, *R. pennsylvanicum* Lam., *R. saxatile* Pall., *R. rigens* Hort., and *R. missouriense* Nutt. On the other hand, other observers have found those species which seem most nearly immune rusted somewhat. *R. grossularia* seems to be least affected of any species upon which observations have been made by a number of different investigators, but it is not always immune. Poirault (1890) cites it as affected and Klebahn (1895 *a*) made successful inoculations upon *R. grossularia* which had been grafted on *R. aureum*. The writer has made successful inoculations on the variety of *R. grossularia* known as "Triumph."

While there are some species of Ribes which are nearly or quite immune, there are others which are especially susceptible. *Ribes nigrum*, *R. aureum*, and *R. rubrum* have been reported by most observers as most seriously diseased. Probably this susceptibility is in some degree due to the fact that these species are the ones most commonly cultivated, and hence the disease is more often noted on these species than on wild ones.

As previously stated, the possible hosts of *Cronartium ribicola* in the genus Pinus are well distributed throughout the north temperate zone. But the genus Ribes has an even wider and more universal distribution. The species of the world are about fifty in number.[a] Throughout the territory covered by their combined ranges the wild species are almost ubiquitous. There are many species of Ribes in America, while Asia has comparatively few. The universal cultivation of Ribes in Europe makes up for the smaller number of

[a] According to Engler and Prantl's Pflanzenfamilien, vol. 3, pt. 2*a*, 1890, p. 89.

native species there. The cultivated species are favorite garden fruits with all peoples and are found throughout the most extensive of cultivated areas. The cultivated species thus occupy just the territory which the wild ones do not. A better group of hosts could hardly be conceived for the rapid and universal distribution of a fungus over immense regions of the earth's surface.

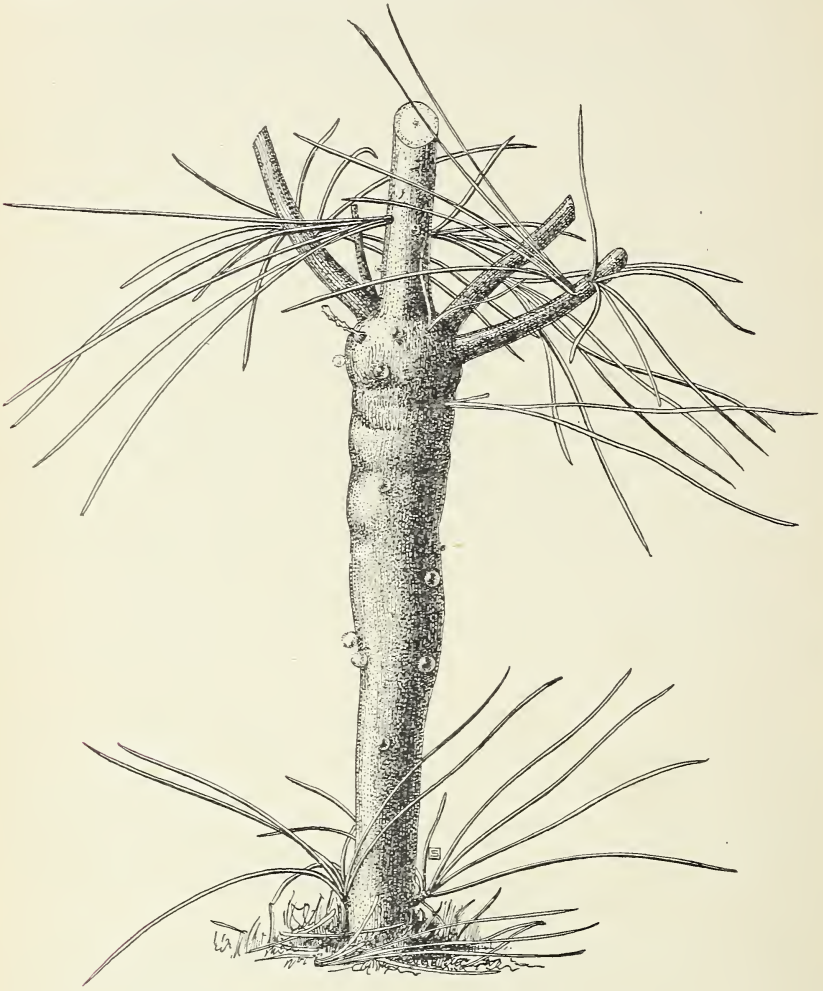


FIG. 3.—A diseased young tree of *Pinus strobus* with pycnidial drops.

LIFE HISTORY OF CRONARTIUM RIBICOLA.

The sporidia produced by the teleutospores on leaves of Ribes are blown indiscriminately by the wind to all sorts of plants which may be in the vicinity. They alight and stick to various parts of such pine trees as happen to be near by. Those which adhere to the

bark of young stems or branches of five-leaved pines find congenial surroundings, and if there is sufficient moisture present for their germination they extrude a germ tube. This tube penetrates the thin young bark tissues and finds therein suitable conditions for further growth. It extends its field of action rather slowly until an area along the stem from one to several inches in length is affected. This infection of the young pines must take place after the latter part of July, as this is the earliest date on which the teleutospores have been found.

The fungus causes no external symptoms of disease in the infected pine for one to several years, at which time the inner layers of bark begin to thicken noticeably. This increase in thickness continues until the bark is often two or three times its normal thickness (Pl. II, fig. 1). In a large lot of trees, the history of which the writer knows, it was about fifteen months after the probable date of infection when hypertrophy began. After the swelling has become noticeable the pycnospores may be formed at almost any time when the weather is suitable for growth (fig. 3). Sometimes progress is slow and the disease does not become noticeable for several years. The earliest age at which pines show the disease is apparently three years, while they may be four or five years old before showing any signs of the trouble when infected in their second year. A few statements have been found that 2-year-old trees may be diseased, but the writer has seen none of this age visibly affected (Spieckermann, 1905; Pechon, 1907; Rostrup, 1902). This indeterminate period of incubation is what renders a single inspection of small value. Such an inspection will result in the removal of those pine trees which have already developed the disease far enough for it to be visible externally. Some months later there may be still other trees which will then show the disease, but which in the first inspection were apparently healthy. It will require several inspections one year apart to weed out all of the diseased trees in an infected lot. The swelling may be concentrated about a single point in the stem, in which case it changes the normal cylindrical shape to a spindle shape, usually tapering upward, but often in the reverse direction (figs. 3 and 4). In a few cases the hypertrophy extends the whole length of one year's growth of the stem, peculiar wart-like bunches forming locally, the entire affected portion having a peculiar and very characteristic obese appearance (Pl. II, figs. 1 and 2; and text fig. 3).

The pycnidia are produced from June to September, according to Klebahn, who has made the closest study of the fungus. This is probably the time when most of them appear. The writer has seen them as late as the latter part of October in the Adirondacks and has noted their appearance on plants in the greenhouse within a month after

being taken from the field, i. e., the latter part of November (fig. 3). This would indicate a production of these peculiar spore bodies quite early in the spring on such plants as have shown decided swelling the previous autumn. It is likely that they appear in the spring on such plants even before the æcidia, i. e., in March or early April. This is

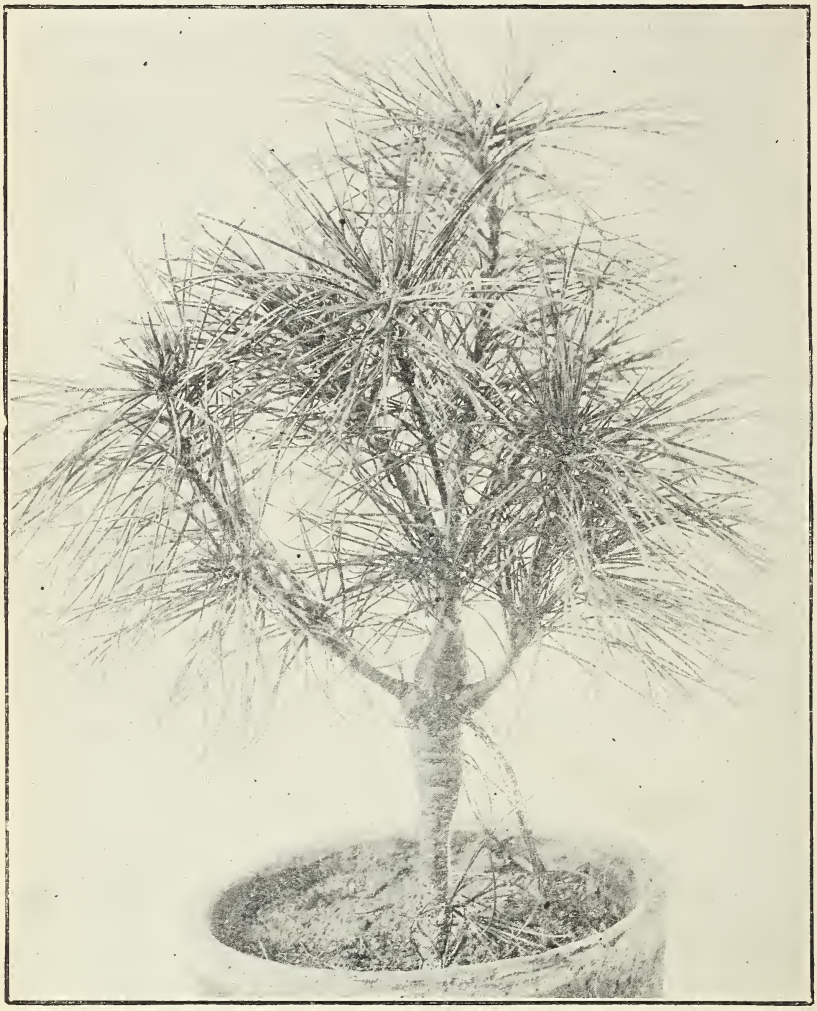


FIG. 4.—A 4-year-old white pine tree showing marked swelling extending upward in the lateral branches, as well as in the stem.

thought to be the case, since in general the pycnidia seem to be forerunners of the æcidia, commonly maturing before the latter.

Early in the spring, after the swelling of the stem is noticeable, the æcidia are formed at one or more places on the swollen bark. If the disease has not progressed enough for the fungus to have attained

much strength, only a single pustule is formed; if the fungus has made a luxuriant growth there may be 10 or 15 or more separate pustules, according to the size of the tree, located on the swollen part (Pl. I, *A*; Pl. II, fig. 2). The disease appears usually only on that part of the stem or branch which is three years old or older, i. e., that part where the leaves have been shed (Pl. I, *A*). These pustules are formed from early April (Klebahn, 1890 *b*) to the early part of June, appearing in the greatest number in the month of May. This varies much according to location and character of the season, however. They break through fissures in the bark, appearing first as rounded bodies of one-eighth to three-eighths of an inch in width and one-fourth to one half inch in length, and yellowish-white in color from the color of the orange spores within the white membranaceous peridium. After a short time the peridium breaks open irregularly, allowing the inclosed spores to fall out and be borne away by the wind (Pl. I, *A*; Pl. II, fig. 2). Klebahn (1904 *a*) states that an æcidium will produce spores for at least fourteen days. By the time in the spring that the spores are freed the young Ribes leaves are formed, so that the spores fall upon them, germinate, and infect them.

The distance to which the uredospores or the æcidiospores may be carried by the wind naturally varies with the local conditions. Plowright (1892 *b*) found diseased white-pine trees 15 yards from affected Ribes bushes. Lauche found the two hosts, both with the rust, 20 meters (66 feet) apart (vide Magnus 1891 *a*, 1891 *b*). Von Tubeuf (1901 *c*) in a paper on the distribution of fungous spores by wind mentions the known distribution of Gymnosporangium spores for several hundred meters. He speaks of two instances of the distribution of *Cronartium ribicola* (1901 *c*), in one case to a distance of 120 meters (396 feet) and in the second to 500 meters (1,650 feet) both to Ribes from *Pinus strobus*. In 1898 (Hollrung, 1898), the Prussian Ministry of Agriculture, Public Domains, and Forests issued an order requiring white pine to be planted at a distance of at least 50 meters (165 feet) from Ribes and the planting of another kind of tree between the two to prevent the wind carrying the spores from one to the other. Magnus (1891 *a*, 1891 *b*) mentions the occurrence of *Cronartium ribicola* on Ribes only 20 meters (66 feet) distant from diseased *Pinus strobus*. Hess (1900) recommends that the two host genera be separated for a distance of at least 50 meters (165 feet). Marchal (1901) recommends a distance of 30 meters (99 feet).

In the work done during 1909 in the removal of Ribes from the vicinity of white-pine plantations, 300 feet or 99 meters was taken as a safe distance. In all States but Vermont Ribes were removed from that distance around the plantations. In Vermont 500 feet (151 meters) was taken as a safe distance. In 1910 New York also took 500 feet as the width of the safety zone.

The æcidiospores germinate within a few hours if there is sufficient moisture. Klebahn (1904 *a*) states that they will remain viable for five weeks, while the writer has germinated them after they had been kept dry in the peridium for five months. The supply of moisture apparently must be plentiful, for an inoculation experiment made by the writer with fresh æcidiospores on currant leaves in the open air utterly failed. The inoculated leaves were not wet, and the test was made during a drought. Nevertheless there was more or less dew nearly every night. Inoculations made by the writer with æcidiospores upon Ribes where the inoculated leaves were heavily wet and then kept under bell glasses resulted in heavy infection. Ewert (1903) says that in 1902 the weather was moist enough to favor the spread of the fungus. Schellenberg (1904) tried unsuccessfully to inoculate Ribes leaves with the æcidiospores and attributed his lack of success to sunny weather. Klebahn (1904 *a*) states that they germinate easily in a moist chamber, and in his description of inoculation experiments with the rusts shows a drawing of an elaborate moist chamber containing the plant to be used in making inoculations.

The æcidiospores can not infect pines if we may accept the evidence of other species of Cronartium. Furthermore, repeated tests made by Klebahn (1904 *a*) have resulted in total failure.

In ten to twenty-one days after infection of Ribes leaves the uredo pustules show under the epidermis and break through it on the underside of the leaves, liberating the spores (Pl. I, *B* and *C*). The uredospores serve to spread the fungus still further on Ribes, as they were believed to have the power to infect Ribes leaves. Inoculations made by Hedgcock, of the Bureau of Plant Industry, with uredospores upon Ribes have proved this to be true. In this way a few scattering infections by æcidiospores may lead to very plentiful and heavy infection of all Ribes in the vicinity. The uredospores are produced in tiny pustules which break through the epidermis and form small masses of the yellow spores heaped up in tiny rounded piles above the level of the epidermis (Pl. I, *C*). They are mainly distributed by the wind, but insects probably carry them to other leaves and near-by plants. The uredospores will germinate at once, producing a simple germ tube similar to that of the æcidiospore; indeed, the uredospores resemble the æcidiospores so much in many ways that Klebahn discussed them together under the same heading in "Die Wirtswechselnden Rostpilze," not distinguishing between the two in many statements. How long the uredospores may retain viability is uncertain, but probably as long as the æcidiospores under the same conditions. The length of time from infection with uredospores to the formation of new uredospores is about fourteen days, the above-mentioned inoculations yielding results in this time. It is always stated that the uredospores infect only the leaves of currants and

gooseberries. There is reason to think that the rust may occasionally live over winter on Ribes, but the leaves are shed every autumn and there seems to be no adequate way of explaining such possible overwintering except by the formation of uredo pustules on the young shoots. The finding by the writer of spore pustules on young twigs of a plant of Ribes which was attacked by a leaf-inhabiting Puccinia (see footnote, p. 16) seems to indicate the correctness of this supposition. The uredospores have been found from the latter part of May (Magnus, 1891 *a*) to the time of the shedding of the Ribes leaves.

After a few weeks yellow to brown threadlike outgrowths form in the uredo pustules (Pl. I, *D*). These are the Cronartium filaments upon which the teleutospores are borne. In artificial inoculations on Ribes leaves the teleutospores have been formed about six weeks after the infection took place (Klebahn, 1888 *b*). They have been found occurring naturally in the field from July (Schroeter, 1889; Von Tubeuf, 1898 *b*) to the fall of the leaves and even on the fallen leaves. The teleutospores may germinate at once; how long they may retain viability is unknown, but presumably for a considerable period of time. When germination takes place, a simple germ tube is extruded and this soon produces a number of simple, thin-walled, cylindrical to ovoid conidia or sporidia. These are blown to neighboring white-pine trees, there to begin again the complicated life cycle of the fungus. The sporidia apparently must be distributed very largely by the wind. Owing to the long time elapsing between infection and the first appearance of disease (one to several years), little or no definite knowledge exists concerning the distance to which these spores may be carried. Commonly rusted Ribes are found quite near diseased pine trees, so it seems likely that this form of spore is not very widely distributed from the center of production. We are also ignorant as to the power which the sporidia possess of surviving desiccation. They are so thin walled that it seems likely that they will survive but a slight degree of dryness. Should this be true, their fields of efficiency would be very much restricted, since their chief means of distribution would usually be a factor in producing unfavorable dryness. Possibly insects play a small part in carrying them to neighboring plants, but so far as we know this takes place only accidentally.

The evidence all seems to favor the view that any or all forms of spores of *Cronartium ribicola* may infect the host plants in uninjured tissues. The Uredinales are among the most strictly parasitic of the fungi. Infection may probably take place at any time when the spore comes in contact with the proper part of the proper host, provided suitable conditions for germination occur. These conditions for germination are a sufficient amount of moisture and heat.

NOMENCLATURE OF CRONARTIUM RIBICOLA.

THE SCIENTIFIC NAME.

In 1856 Dietrich first used the name *Cronartium ribicola* in a publication. Here it was used without any description, and hence is apparently a *nomen nudem* and invalid. But Dietrich referred to "Crypt. 4:21," evidently meaning some set of exsiccatæ containing specimens of the fungus. In 1852–1857 Dietrich issued such exsiccatæ entitled "Plantarum Florae Balticae Cryptogamarum." It is almost certain that the reference mentioned above refers to these exsiccatæ. Whether the specimen of *Cronartium ribicola* in these exsiccatæ had a description upon the label is unknown. That this is the case seems very probable when we remember that European writers almost invariably credit the name to Dietrich. The writer has been utterly unable to find the exsiccatæ anywhere in this country, and hence is unable to say what is the real state of affairs. Except for Dietrich's own citation and a reference in Lindau and Sydow's Thesaurus Litteraturae Mycologicae no mention of the exsiccatæ has been found. Evidently there were not many copies issued. Arthur (1907) cites the name as *Cronartium ribicola* Fischer von Waldheim in Rabenhorst's Fungi Europaei Exsiccatae, No. 1595, this evidently being the first description published since Dietrich's time. But Klebahn (1904*a*) distinctly states that Dietrich named and described this fungus in 1855. In either case the name is the same. In 1887 Klebahn separated *Peridermium strobi* from *P. pini* and named and described it. Rostrup in 1890 apparently named it *P. klebahni*. The status of the name of this stage is immaterial, since the name of the Cronartium state is oldest and holds good for the species in any case. The name *Cronartium ribicola* has been used for both stages of the fungus in this bulletin, since *Peridermium strobi* is a synonym only.

THE COMMON NAMES.

Cronartium ribicola and the disease which it causes have received a number of common or vernacular names which are more or less appropriate. The rusty appearance of the masses of spores has led to the terms "currant rust" and "Weymouth pine rust," the white pine being quite generally known in European countries by the name Weymouth pine, from Lord Weymouth, who first brought it into prominent notice in Europe. Any plant disease which results in a brown or reddish appearance of the affected leaves is likely to be called a "rust" popularly, no matter whether caused by a fungus, an insect, or insufficient or improper food and water supply. A name

is needed which will not lead to such a confusion of totally different diseases. The Germans are usually very apt in making common names, and their names for the two stages of this fungus are especially applicable and appropriate. The rust on the currant leaves is known as "Filzrost" (felt rust) from the coarse hair-like outgrowths of the teleutospore stage, while the stage on the white pine is called "Blasenrost" (blister rust). Both names refer to the appearance of the fungus and are sufficiently distinctive to avoid confusion even in the popular mind.

DESCRIPTION OF CRONARTIUM RIBICOLA.

Arthur's description of the fungus *Cronartium ribicola* is probably the most complete yet given, and it is used herein with certain additions by the writer on points which have not previously been mentioned.[a]

Pycnidia caulicolous, scattered, honey yellow, forming minute, bladdery swellings exuding a sweet fluid. *Pycnospores hyaline, ovoid to elliptical, 1.9–4.7 μ.*

I. Aecidia caulicolous, *causing fusiform swellings of the stem or branches in most cases*, rounded to elongate; peridium inflated, rupturing at sides, thick, membranous, cells isodiametric, smooth or nearly so on outer surface, verrucose on inner surface; æcidiospores ellipsoid *to ovoid*, 18–20 by 22–23 μ; wall colorless, coarsely verrucose except on elongate smooth spot, 2–2.5 μ thick, on smooth spot 3–3.5 μ thick.

On Pinus strobus in Germany, Austria, Russia, Finland, Siberia, Sweden, Norway, Denmark, France, England, Belgium, Netherlands, Italy, and Switzerland. Introduced into the northeastern United States and Indiana, Ohio, and Ontario, Canada, in 1909.

On Pinus cembra in Russia and Switzerland.

On Pinus lambertiana in Germany.

On Pinus monticola in Germany and England.

On Pinus excelsa in Denmark.

II. Uredinia hypophyllous, thickly scattered in orbicular groups 1–5 mm. across, round, pustular, small, 0.1–0.3 mm. across, dehiscent by a central opening, at first bright yellow; peridia delicate, inner walls thicker than outer walls; uredospores ellipsoid to obovate, 14–22 by 19–3.5 μ, wall colorless, medium thick, 2–3 μ, sparsely and sharply echinulate.

III. Teleutal columns hypophyllous, cylindrical, 125–150 μ thick, up to 2 mm. long, curved, bright orange yellow, becoming brownish; teleutospores oblong or cylindrical, 8–12 by 30–60 μ, rounded or obtuse at both ends; wall nearly colorless, smooth, rather thick, 2–3 μ.

On Ribes aciculare, alpinum, americanum, aureum, aureum var. *leiobotrys, aureum* var. *palmatum, bracteosum, cynosbati, divaricatum, gordonianum, gracile, grossularia, grossularia* var. *arboreum, heterophyllum, intermedium, macrobotrys, menziesii, multiflorum, nigrum, nigrum* var. *aconitifolium, nigram* var. *crispum, nigrum* var. *laciniatium, orientale, oxyacanthoides, parvifolia, petraeum, prostratum, rotundifolium, rubrum, sanguineum, saxatile, setosum, and triste in Europe.*

On Ribes rubrum at Sapporo, Japan, and on Saghalin Island.

On Ribes longiflorum Nutt. in Kansas.

On Ribes rubrum, R. nigrum, R. aureum, R. grossularia, and R. irriguum in New York.

[a] The italicized portions, with the exception of the names of hosts, are supplied by the writer.

FIELD CHARACTERS OF THE BLISTER RUST ON PINUS STROBUS.

White-pine trees affected with the blister rust have been seen by the writer which were 3, 4, 5, 6, or 7 and 10 years old. Many that have been seen were diseased on the second year's wood, while some have had the third year's growth affected. In some instances the disease has started at the upper end of the second year's growth and then extended into the third year's growth (Pl. I, *A*). In a few cases it has started in the main stem at the upper end of a year's growth and then spread into the bases of the branches at that point, causing the characteristic tapering swelling in the branches as well as in the stem (fig. 4).

The affected trees are peculiarly stunted in appearance, the tops in many cases having a bunchy growth so characteristic that they can easily be picked out from their healthy fellows by this character alone (Pl. II, fig. 1). The new growth of the last season is usually shorter than in healthy trees (Pl. II, fig. 2), and the new needles are apt to be somewhat yellowish in color. The normal stem is nearly uniform in size throughout each year's growth, while the wood of each year varies in diameter from that of other years. Trees affected by *Cronartium ribicola* usually have the stem swollen at one end of a year's growth. The swelling usually is in the shape of an elongated cone, rising quite abruptly to its maximum diameter and then tapering gradually down to the normal stem diameter (fig. 3; Pl. I, fig. 1).

In some cases the entire length of the year's growth is swollen irregularly and has a peculiar obese appearance (fig. 3). Scattered along this swollen area are a number of wart-like bunches, usually situated at old leaf scars.

The swellings on the stems and branches are usually located on wood which is at least three years old and has no needles, so they are easily detected. Where the disease has been present for a number of years the bark becomes irregularly cracked and fissured and abnormally thickened (Pl. II, fig. 1). The swelling in all cases seems to be caused by a decided thickening of the inner bark and bast tissues, resulting later in an increased production of corky tissue, the wood being very slightly, if at all, affected.

The fungus is capable of living indefinitely in the bark as long as the host tree remains alive. Fortunately, in far the larger number of cases the host succumbs in one or two years and the parasite being unable to live on dead material dies also. In such cases the bark becomes loosened around the stem, dies, and thus the fungus girdles the tree or branch and causes the death of the parts above. Sometimes the tree is girdled without perceptible swelling taking place, but this is not common (fig. 5).

One or more years after infection occurs, the infected stem or branch begins to show swelling, as just described. The swelling develops quite rapidly, probably within one or two months after starting. When it has become noticeable, small, more or less transparent, spots form. These develop into minute, blister-like bunches, surrounded at the base by a translucent spot, through which the yellow endochrome of the developing æcidial stage shows. A little later the blisters break open and exude tiny drops of a sweet, yellowish, sticky fluid. Examination with the microscope shows this fluid to be filled with myriads of tiny hyaline spore bodies (fig. 3). These may develop at any time from early spring to late autumn. Later, after a period of time of uncertain length (known in one instance to be about a year), the peridermium or æcidial spores are formed in pustules scattered over the swollen part. These pustules are rounded to elongate in outline, one-eighth to one-half inch by one-eighth to one-fourth inch. At first the bark breaks open, and a rounded mass of an orange color pushes through the fissure. This attains a height of one-eighth to one-fourth of an inch and breaks open irregularly, allowing the powdery contents to escape (Pl. I, fig. 1; Pl. II, fig. 2). After the spores are given off, a delicate whitish membrane is left standing upright around the edges of the fissure and projecting somewhat from it. Still later this also disappears, and one finds only an empty depression in the bark with more or less rounded outlines and with some whitish masses of material in the rough bottom, which, upon examination, prove to be masses of spores. These empty fissures are so characteristic that they may be easily recognized at once, even by the unaided eye. The yellow pustules, either before opening or after, are also very characteristic, and are likely to be found between the last of April and the middle of June. The whitish membrane may be found at any time from June 1 to late autumn; the empty fissures where the spores were earlier produced may be found at any time after June 1. Many times trees

FIG. 5.—Two young trees of *Pinus strobus* with constrictions caused by *Cronartium ribicola*.

are found which have the swollen stem, but no spores or traces of pustules. These can usually be distinguished from trees affected by any other form of injury. An injury to the bark usually results in the formation of a swelling on the edges of the wound, but this can easily be distinguished from the hypertrophied condition brought about by *Cronartium ribicola*.

SOURCE OF DISEASED STOCK FOUND IN AMERICA.

Without a single exception, in 1909 diseased lots of white pine were traced to a common origin, i. e., the nurseries of J. Heins Söhne, at Halstenbek (Schleswig-Holstein), Germany. In a recent article Von Reitzenstein (1909) makes the statement that this disease is not present at Halstenbek, although admitting that it has been so serious that it caused discrimination against stock grown there. We are credibly informed that the State of Hesse-Darmstadt has officially forbidden the use in the State and communal forests of white pine raised by J. Heins Söhne at Halstenbek; also that this firm denies ever having had the disease.

Our investigations have shown not only that these nurseries have had this disease, but that it occurred there in the years 1908, 1907, 1906, 1905, and 1903. Importations inspected by members of this office made in the spring of the years succeeding these dates have had diseased trees. The disease (usually with fruiting bodies of the fungus) has been found upon trees 10, 7, 6, 5, 4, and 3 years of age which came from this nursery. The firm mentioned has shipped diseased stock to 226 out of the 230 known localities where such stock has been received in North America.[a]

A very peculiar feature was the great uniformity with which the disease occurred in all the shipments from this firm during 1909. Practically every lot of trees which were 3 years old was found to have some of the disease, in many cases the sporophores being found upon the dead and dying trees as well as upon trees which would certainly live one or more years longer. The proportion of diseased trees seems to be very uniform in all the lots of 3-year-old ones examined by the writer. Usually infection with a fungous disease occurs irregularly. The uniformity of infection in this case argues for the uniform presence of Ribes near a considerable portion of the nursery or a deliberate segregation of such stock for shipment to this country.

As already stated, lots of diseased white-pine trees were received in 1910 from the following firms in France: Levavasseur & Fils,

[a] Moreover, stock has been received from this firm in the spring of 1911, which, when unpacked, bore fruiting bodies of the blister rust.

Ussy; Barbier & Co., Orleans; and E. T. Dickinson, Chatenay. It is still uncertain whether these firms raised the diseased trees themselves or not.

THE BLISTER-RUST SITUATION IN AMERICA.

IMPORTATIONS OF SUSPECTED STOCK.

On June 5, 1909, the writer was asked to examine some young white-pine trees, which had been imported from Germany shortly before, for the purpose of determining whether they bore fruiting bodies of *Cronartium ribicola*. The trees had died after being set out in the field and such fruiting bodies as had been present, if any, had been washed off by heavy rains, so that the writer at the time was unable to decide as to the presence of the fungus. The spring before, a large lot of 2-year-old trees had been imported from the same nursery and had been examined at that time for the fungus, with absolutely no indications of it having been found. These were in June, 1909, again examined by the writer and the fungus was found to be present upon a considerable number of the then 3-year-old trees. Exactly the same thing has happened with 2-year-old trees imported in 1909, which have developed the disease in 1910. Further investigation showed that the disease had been imported upon trees in the spring of 1909, as well as upon the above-mentioned ones of the same age which were imported a year before. Suspicion thus rested upon all the trees imported in 1909 from the same nursery, and it was found that such trees had gone to the States of New York, Vermont, New Hampshire, Massachusetts, Connecticut, Pennsylvania, Minnesota, and to Ontario, Canada.

In 1910 the New York horticultural inspectors discovered diseased white-pine stock received from Barbier & Co., Orleans, France. The horticultural inspectors of Ohio also discovered diseased stock in that State which came from the other two French firms already named on this and the preceding page.

THE BLISTER RUST IN NEW YORK.

The situation in New York was attacked with the greatest vigor as soon as the presence of the disease was known. Mr. C. R. Pettis at once brought the matter to the attention of Mr. J. S. Whipple, Forest, Fish, and Game Commissioner, and arrangements were immediately made for a meeting of the representatives of the forestry interests involved, or likely ultimately to become involved, to be held in the city of New York. At this meeting those then involved pledged united action against the disease, each State Forester agreeing to begin at once the removal of Ribes from the vicinity of the plantations of diseased trees in his State. In New York this work

was carried on by the Forest, Fish, and Game Commission in cooperation with the State Department of Agriculture. Letters were sent to the persons having lots of the trees from J. Heins Söhne, telling them of the discovery of the disease and asking the owners to remove the Ribes within their plantations, as well as within 100 yards of their outer limits. While this resulted in considerable help, the inspectors usually had most of this work to do, but considering the difficult nature of the work the entire State was covered in a short time. That this was accomplished none too quickly was shown by the discovery of a single case where the fungus had transferred from the imported pines to currants near by. The spores were still inclosed beneath the epidermis of the currant leaves, so that not one had yet been set free. Only uredospores were formed, which are unable to infect pines, so the disease was checked in the nick of time. This State, which has had more imported trees than any other, proposes to insure freedom from disease in the future by stopping the buying of foreign stock and by raising its entire supply. In 1910 all importations of white pines were again inspected and the diseased trees destroyed. The work this season showed that the Ribes are again sprouting up where they were removed in 1909. The safety zone was increased from 300 to 500 feet in width in 1910.

THE BLISTER RUST IN VERMONT.

The trees in Vermont, like those in New York, were obtained of J. Heins Söhne. What has been said of New York in regard to the action taken against the blister rust is also true of Vermont. The State Forester handled the entire matter with advice from the State Botanist as to procedure. Here the safety zone around the infected plantations was made 500 feet wide instead of 300. The Ribes were removed, and the affected pine trees destroyed in all the plantations of the diseased trees. No more imported trees will be distributed by the Vermont State Forester. In 1910 the plantations of imported trees were again inspected and the diseased trees destroyed.

THE BLISTER RUST IN NEW HAMPSHIRE.

No trees were supplied in New Hampshire by a State Forester and no plantations were made of imported stock except a few scattering ones made by people who imported their own supply. Most of these were inspected by the writer in 1909 and 1910.

THE BLISTER RUST IN MASSACHUSETTS.

In Massachusetts the imported trees, also from J. Heins Söhne, were set out on State lands and were not distributed to private parties to set upon private lands, as was the case in New York, Connecticut, and Vermont. The problem was accordingly much simpler.

The State Forester ordered the removal of Ribes from the plantations, and his order was carried out in good season. The native *Ribes prostratum* was plentiful upon some of the lots and entailed much thorough and painstaking labor for its complete removal. Diseased pine trees were found in immediate proximity to the Ribes, but fortunately none of the latter were found infected when they were removed.

THE BLISTER RUST IN CONNECTICUT.

In Connecticut the imported trees were distributed to private parties throughout the State. The trees were obtained from J. Heins Söhne. Most of the inspection in 1909 in this State was done by the writer and Dr. A. H. Graves, Special Agent of the Bureau of Plant Industry, owing to the absence of the State Botanist in Japan until late in the season and the resignation of the State Forester, who accepted a similar position in Vermont shortly before. A large part of the State was covered and the State authorities agreed to complete the work in 1910. Several large private importations were also inspected in this State by the writer. Arrangements have been made to obtain the future supply of trees in this country.

THE BLISTER RUST IN PENNSYLVANIA.

Several privately owned plantations of white-pine trees in Pennsylvania imported from J. Heins Söhne were inspected by Prof. J. F. Collins, Special Agent of the Bureau of Plant Industry. These have had the diseased trees and Ribes removed and destroyed. Last spring (1910) a very large lot was discovered by the writer and has been inspected by the State Nursery Inspector.

THE BLISTER RUST IN MINNESOTA.

A single lot of white-pine trees from J. Heins Söhne is known to have gone to Minnesota. The State authorities inspected these trees, but no diseased ones were found.

THE BLISTER RUST IN OHIO.

Diseased trees have been found by the State Horticultural Inspector in Ohio in two different places. These were received from the two French firms of Levavasseur & Fils, Ussy, and E. T. Dickinson, Chatenay. It is not known whether they were raised by these firms.

THE BLISTER RUST IN INDIANA.

A diseased lot of white pines has been reported by the Indiana State Entomologist as having been found in that State recently.

THE BLISTER RUST IN ONTARIO, CANADA.

Some of the trees from J. Heins Söhne went to Ontario. The Dominion authorities have agreed not to import further and Canada has prohibited the importation of white pine affected with this disease.

There are, doubtless, other scattering lots of diseased trees which have come into the country, especially to ornamental nurserymen. It is earnestly hoped that the owners will promptly notify the Office of Investigations in Forest Pathology of the Bureau of Plant Industry about them, so that they may be inspected and the presence or absence of the disease determined before the fungus has obtained a foothold on native white-pine trees in the vicinity.

METHODS OF COMBATING THE BLISTER RUST.

PREVENTIVE MEASURES AVAILABLE IN AMERICA.

American nurserymen have one effective method of combating the blister rust, i. e., to stop importing European stock of any of the five-leaved species of pine. A nurseryman who imports no five-leaved pine and who allows no imported Ribes to grow near his nurseries need have no fear of the blister rust. Those nurserymen who import or handle imported stock of Ribes must maintain a rigid and carefully planned and executed inspection of such stock during its first season in their grounds and keep such stock segregated from other Ribes and white-pine stock or they may find themselves unexpectedly faced with this serious trouble. In places where the disease is already present, the only course is to remove the least valuable of the two hosts and destroy all diseased plants of the remaining host. Two or three inspections in July and August at intervals of ten days to two weeks should make sure of all infected Ribes if the diseased and suspected ones are each time destroyed when found. In an infested lot of pines, inspections made during the month of May for several consecutive years should be sufficient, provided all suspicious trees are at once burned. In the case of an infected plantation or nursery of pines all wild and cultivated currants and gooseberries should be promptly removed to a distance of 500 feet from the edge of the area containing the pines. The pines should be very carefully inspected and all trees which show the least signs of this disease should be burned at once. Another inspection the following spring should result in the removal of those infected trees which were not detected the first time. If none be found in the second inspection it is probable that all the diseased trees were found in the first inspection. Owing to the indefinite period of incubation of the fungus it is

unlikely that a single inspection will result in the removal of all of the infected trees.

All white-pine trees imported before they are 3 years old should be inspected when they reach that age, as the disease does not usually become visible on younger trees. A few writers have mentioned it as occurring upon 2-year-old trees (Spieckermann, 1905; Pechon, 1907; Rostrup, 1902), but this seems to be exceptional and is not known to occur in this country. It is advisable that imported trees be held in nursery rows for at least one year in order to determine beyond a doubt whether the disease is present.

Any person buying young five-leaved pine trees should require the seller to guarantee the stock to be free from this disease, or, better still, to have been raised in America, since foreign stock is liable to be diseased.[a] Foreign seed will not carry this fungus, and is perfectly safe so far as the blister rust is concerned.

The Office of Investigations in Forest Pathology will teach inspectors the characters of the disease and so far as possible will make inspections where there are no State inspectors or where local inspectors are unable to do so. Specimens of trees or of Ribes leaves will be promptly examined and the results reported, with suitable recommendations for treatment. It is recommended that shipments of imported trees be reported to the office mentioned, together with the name of the nursery or firm from which they were obtained. This will enable it to take prompt action in notifying owners of new developments in regard to treatment, etc.

RECOMMENDATIONS OF EUROPEAN WRITERS.

Eriksson (1896 *a*) made the following recommendations for combating this disease in Sweden: Inspect plantations and nurseries in April and May; cut out diseased branches in old trees and burn them; cover infected places with tar or tar and lime to prevent spermogonia and æcidiospores being set free; remove white pines from vicinity of currants; collect and burn rusted currant leaves in late spring; raise young trees from seed of healthy trees.

Schøyen (1897, 1901), in Norway, recommends removing diseased Ribes bushes from white pines.

Hollrung (1898) cites recommendations issued by the Prussian ministry of agriculture, domains, and forests, as follows: Destroy affected seedlings; in new plantings place white pine at least 50 meters from Ribes, and plant another kind of tree between the two.

[a] Persons insisting upon importing white-pine stock will endanger themselves and the rest of the country somewhat, even after they take all precautions in inspecting such foreign stock and eradicating diseased trees.

Weiss (1899, 1900), in Bavaria, admonishes owners of nurseries to see that only healthy trees are sold, also that only trees more than 4 or 5 years old be bought, since the disease shows before this time.

Hess (1900), in Germany, says that buyers should require proof of the good health of stock before buying and planting out; they should also remove and burn diseased trees and remove Ribes for a distance of at least 50 meters.

Nypels (1900), in Belgium, says that Ribes in the vicinity of a diseased nursery or plantation of pine should be destroyed.

Marchal (1901), also in Belgium, recommends burning diseased trees or parts and the removal of Ribes to a distance of 30 meters.

Von Tubeuf (1905 *b*, 1905 *a*), in Germany, mentions burning of diseased trees and bushes, the separation of the two hosts, the picking off of diseased Ribes leaves, and the raising of stock from seed in order to be free from this disease.

Pechon (1907), in Belgium, recommends planting *Pinus strobus* in mixture with other species, obtaining stock from a nursery known to be free from the disease or raising it for one's self, burning affected trees, and separating Ribes from pines. He also says painting with tar and other similar methods are not efficient.

Schelle (1909) recommends spraying with a solution of 2 per cent of copper sulphate and 2 per cent of lime to prevent the distribution of spores.

In considering these recommendations of European writers we must remember that the aim in Europe is *not* complete eradication, since the fungus is so prevalent and universally distributed that this is plainly impossible. The object is simply to keep the fungus down to such a point that it will do little damage. Here in America we have every opportunity thoroughly to eradicate the fungus which is already in the country and to be sure that no more is allowed to come into the country. In the cases of a locality in Kansas and at Geneva, N. Y., the fungus has already been eradicated successfully. The life history of the fungus is such that there is a very good chance to do this before it becomes established.

EFFECT OF NEW HOSTS AND CLIMATE UPON THE VIRULENCE OF FUNGOUS PLANT DISEASES.

It is a well-known fact that a fungous disease of plants when introduced into a favorable new climate or attacking new hosts is apt to become more virulent and cause greater damage and more complete destruction than when in its native climate or on native hosts. It is also true that such diseases do not run out after a few years and disappear. A new fungous disease established in a new country with a favorable climate is a permanent factor and must be reckoned with

ever after. While we fortunately have rather few instances of such diseases, those that we do have corroborate these statements. The following cases are well known and serve to bring out these two points.

One of the most disastrous instances of the introduction of a parasitic fungous disease into new countries was that of the grape mildew (*Uncinula necator* (Schw.) Burr.).[a] This fungus was native in America on wild species of vines. In 1845 it was first discovered in Europe in England. The next year it spread around the original neighborhood in hothouses. In 1847 it was found in one locality in France and the next year occurred in several localities there and also in Belgium. In 1850 it devastated the vineyards around Paris and was found in Spain and Italy. In 1851 it was general in the French vineyards and those of the Mediterranean basin; it was also newly reported from Hungary, Greece, Switzerland, Syria, Asia Minor, and Algeria. In 1852 it broke out in Madeira and in 1866–67 it appeared in Australia. Except as mentioned the damage was not great, but in 1852, 1853, and 1854 the yield of the French vineyards was reduced to a tenth or twentieth of the normal crop. The population of certain districts emigrated. After 1855 the damage decreased. The disease is still present every year and causes great losses; methods of combating it have, however, been found, so that it is greatly checked. But we do not have to go back of recent years for instances of the introduction of fungous diseases into new regions. As recently as 1900 the American gooseberry mildew[b] (*Sphaerotheca mors-uvae* (Schw.) B. and C.) was first discovered in Europe in Ireland; in 1901 it was present in Sweden and Russia; in 1902 in Denmark; in 1903 in Germany; in 1904 in Finland and Norway; in 1905 in Austria; in 1906 in England and at Tomsk, Siberia; while in 1907 it was reported from thirty-three Governments in Russia.

The best known instance of great damage resulting from the introduction of a parasitic fungus into new regions is possibly that of the potato blight caused by *Phytophthora infestans* De Bary. This was

---

[a] Viala, Pierre. Les Maladies de la Vigne, 1893, pp. 2–4.

Salmon, E. S. A Monograph of the Erysiphaceæ. Memoirs of the Torrey Botanical Club, vol. 9, 1900, pp. 99–105.

[b] Salmon, E. S. On The Present Aspect of the Epidemic of the Gooseberry-Mildew in Europe. Journal of the Royal Horticultural Society, vol. 29, 1905.

Elenkin, A. A. Zhurnal Bolyezni Rastenii, vol. 1, 1907, pp. 3–7.

Eriksson, J. The Gooseberry Mildew in Europe. Its Spread and Prevention. Zeitschrift für Pflanzenkrankheiten, vol. 16, 1906, pp. 83–90.

Herter, W. Die Ausbreitung der Stachelbeerpest, Sphaerotheca mors-uvae (Schweinitz) Berkeley in Europa im Jahre 1906. Centralblatt für Bakteriologie, Parasitenkunde und Infektionskrankheiten, pt. 2, vol. 17, 1907, pp. 764–773.

Salmon, E. S. On the American Gooseberry Mildew and the Need for Legislation. Journal of the Royal Horticultural Society, vol. 31, 1906, pp. 128–137.

apparently native in South America,[a] where it occurs upon the cultivated potato as well as various wild species of the same genus. The early history of this disease is somewhat uncertain, but apparently it was responsible for serious trouble with potatoes in Germany as early as 1830. In 1836 it broke out in the Rhine plain, between Coblentz and Cologne; after this time it gradually spread to Hesse, the Palatinate, and central Germany. In 1842 it certainly was present in Germany and was also discovered in the same year in Belgium and Ireland. In 1845 it was found in England, Scotland, and France. It is said to have been found in the United States as early as 1840; occurred near Boston in 1842, near New York in 1843, and in 1844 was found in Canada and at numerous points in the United States. In 1845 it caused a very serious outbreak of disease in certain parts of Canada, Ireland, and the larger part of Europe. This outbreak continued with great intensity until 1850; in 1851 the intensity decreased. Since this time the disease has spread into practically all parts of the world where the potato is grown. It is present every year in those localities where it has occurred and if weather conditions are favorable serious outbreaks occur.

But the diseases mentioned are caused by fungi quite different from the white-pine blister rust. The following cases are those of rust fungi, but both are capable of living on a single host, and do not require two different ones, as does the white-pine blister rust.

The asparagus rust (*Puccinia asparagi* DC.) was introduced into this countryin 1896 from Europe;[b] within ten years it was spread over practically the entire country and had inflicted a great amount of damage. It is still with us and causes much damage every year.

The hollyhock rust[c] (*Puccinia malvacearum* Mont.) was native in Chile. In 1857 it was discovered in Australia. It was first discovered in Europe in 1869, in Spain; then in France in 1872; in England and southern Germany in 1873; in northern Germany and Italy in 1874; in Switzerland and on the Cape of Good Hope in 1875; in Austria and Hungary in 1876; in Greece in 1877; in Sweden in 1887, and in Finland in 1890. It apparently first entered this country in Massachusetts in 1886,[d] when it was first discovered here. It soon spread throughout the United States and has been present ever since.

Finally we may take *Cronartium ribicola* itself. This was endemic upon *Pinus cembra* in Russia and Siberia and possibly in the Alps.

[a] Prunet, A. Le Mildiou de la Pomme de Terre. Revue de Viticulture, vol. 17, 1902, pp. 663–666.

[b] Halsted, B. D. The Asparagus Rust; Its Treatment and Natural Enemies. New Jersey Agricultural Experiment Station Bulletin 129, 1898, pp. 4–5.

[c] McAlpine, D. The Rusts of Australia, 1906, pp. 43–44.

[d] Dudley, William R. The Hollyhock Rust. New York (Cornell) Agricultural Experiment Station Bulletin 25, 1890, pp. 154–155.

It was first found in the Baltic provinces of Russia in 1855. In 1869–1875 it was epidemic in Finland on *Pinus strobus*. In 1871 it was found in Denmark, and in 1872 in northern Germany. It is now known practically throughout Europe. This distribution is probably the most striking and most rapid of any known instance among the heterœcious fungi. This has had both new climatic conditions and new hosts to increase its virulence in Europe. These factors, as well as others, would greatly favor its spread in America should it once become established here. There seems to be no reason to expect it to be less destructive than it has been in Europe and there is every reason to fear that it may be much more so. This is especially true of the West, where the rusts seem to find their most favorable climate. That this fear is held by foreign mycologists is shown by the following statement by Somerville (1909) of England: "But it is to be feared that the day is not far distant when it will gain a footing in North America, and if it spreads there as it has done in Europe the loss that will result through the destruction of one of America's most valuable lumber trees can only be described as appalling."

PRACTICAL SUGGESTIONS.

DANGER TO ALL FIVE-LEAVED PINES.

The white-pine blister rust is anomalous and almost unique among plant diseases. It originally attacked the stone pine (*Pinus cembra*), which is a native of Europe, the fungus itself being also endemic in Europe. About two hundred years ago the white pine (*Pinus strobus*) was introduced into Europe as one of the most promising of American conifers. It was widely disseminated in the various European countries and even extensively planted in the forests. About fifty years ago the blister rust of *Pinus cembra* was found attacking *P. strobus*. The disease has continued its attacks upon the new host with all its original severity, while upon the stone pine it causes relatively slight damage and does not seem to be spreading rapidly.

Pinus cembra and *P. strobus* are five-leaved species and are quite closely related to each other. The blister rust has been found upon *Pinus monticola* and *P. lambertiana*, which are five-leaved species and are even more closely related to *P. strobus* than is *P. cembra*. They are American species, occurring naturally in the Rocky Mountain region. What is probably the same blister rust has been noted in Denmark upon the Himalaya pine (*Pinus excelsa*), also a five-leaved pine (Rostrup, 1902). The fungus has had every chance to infect other pines in Europe which are not five-leaved, so that it seems to be fairly well proved that it attacks only the five-leaved ones, which belong to the group known as white pines. In the

United States the five-leaved pines occur naturally in the forests of the entire country except the section from Texas and Oklahoma eastward and north to the Ohio River, which is occupied by the southern yellow pines. Even here the white pine (*Pinus strobus*) extends in the Appalachians to northern Georgia and Alabama. Moreover, *Pinus excelsa* and *P. ayacahuite* are commonly planted in this section as ornamentals and their use is increasing. Wild and cultivated species of Ribes occur throughout the entire country, so that it would be merely a question of time for *Cronartium ribicola* to spread over the country if it once becomes established.

WHY THE DISEASE MAY BE EXPECTED TO BE WORSE IN AMERICA THAN IN EUROPE.

When a fungus is introduced into a favorable new climate or attacks new host species it is likely to become more virulent and to cause greater and more complete destruction than before. Such diseases do not run out. When a fungus is once established in a new region it is a permanent factor in the cultivation of its host plants ever after. The histories of the potato blight (*Phytophthora infestans* De Bary), the grape mildew (*Uncinula necator* (Schw.) Burr.), the asparagus rust (*Puccinia asparagi* DC.), the hollyhock rust (*Puccinia malvacearum* Mont.), and other parasitic fungi which have been carried from one continent to another, prove the truth of these statements.

In Europe *Pinus cembra* and *P. strobus* are quite generally distributed, but none of the other known pine host species of *Cronartium ribicola* are very generally distributed there. This practically limits the fungus to the two species *Pinus cembra* and *P. strobus* in Europe. The first is not usually seriously injured, while the latter, as well as the other American host pines, is very seriously injured. Here in America all the native species of five-leaved pines are liable to be attacked. This fungus is exterminating white pine, and is attacking *Pinus monticola* nearly as badly in England (Somerville, 1909). There are numerous other sections where white pine is very seriously injured. With the great variety of climatic conditions which obtain in various parts of America it will be surprising if the fungus does not find some section suited to its best development. We have every reason to expect this disease to be as bad as or worse than it is in Europe if it is allowed to become established here.

ESTIMATES OF POSSIBLE DAMAGE.

A very crude idea of the loss which this disease might inflict may be obtained as follows:

The census returns show that the total valuation of the forest products derived from the five-leaved pines, as far as they are separately

obtained, for the year 1908 was about $65,000,000.[a] If only 1 per cent of the stand was affected, the loss would be $650,000 a year.

Estimates for the year 1909 show that the valuation of the white pine then standing was about $600,000,000,[b] while that of the sugar pine (*Pinus lambertiana*) was about $120,000,000. Taking a loss of 1 per cent (which is very conservative for this, as well as other fungous plant diseases), we have losses of $6,000,000 and $1,200,000, respectively. The smaller alone far outweighs the total valuation of all the five-leaved pine stock that has ever been imported into the country. While the losses would be expected to occur somewhat in older trees, the greater part would be in trees less than 25 years old. Should the situation become as aggravated as it now is in England (Somerville, 1909) the losses would far exceed 1 per cent on all sizes of trees.

Estimates of the extent of the nursery interests concerned with the five-leaved pines are not obtainable. In New England white pine is used in about 90 per cent of all the planting done. It has been estimated that about 200,000,000 [c] feet of lumber may be cut from the present plantations of New England between 1930 and 1950. The writer has collected such data as he could upon the extent of the planting movement in the Northeastern States with regard to the amount of white-pine stock utilized for planting. These data are necessarily fragmentary, being compiled from several different sources, but they much understate the facts rather than exaggerate them. It has been found that the States of New Hampshire, Vermont, New York, Pennsylvania, New Jersey, Connecticut, Rhode Island, and Massachusetts have planted an area of approximately 13,000 acres with this species. In the single year 1909 about 3,000 acres were planted in New York, Vermont, New Hampshire, Massachusetts, and Connecticut. These figures show that the planting movement has reached a really important volume. The setback from the white-pine rust is already perceptible, but it is temporary, being caused only by waiting for American nurserymen to rise to their opportunities and produce healthy stock at reasonable prices. One large company is already offering such stock at a very material reduction in prices from those which have previously been quoted. If the white-pine blister rust becomes a permanent factor in the cultivation of this species in America the planting movement will be

[a] Forest Products, Bulletin 10, Bureau of the Census, Dept. of Commerce and Labor, 1909, pp. 1–137.

[b] Kellogg, R. S. Circular 166, Forest Service, U. S. Dept. of Agriculture, 1909, pp. 8, 19.

[c] Peck, A. S. Report of the National Conservation Commission, vol. 2, 1909, pp. 668–686.

seriously discouraged and greatly checked at the very time it bids fair to accomplish results commensurate with our needs.

ACTUAL COST OF IMPORTED WHITE-PINE STOCK.

The original cost of white-pine planting stock is undoubtedly less in European countries than in America. But a number of other factors must be considered when the actual cost of imported European stock is determined. The following table gives a comparative statement of the various items entering into the final cost of such stock, taking 3-year-old trees as a basis upon which to work.

Total cost of imported white-pine stock.

Cost in European nurseries	$1.50 to $2.50 per 1,000.
Cost in American nurseries	$5 and upward per 1,000.
Cost of boxes for shipping in Europe, about	50 cents per 1,000.
Cost of baskets for shipping in Europe, about	35 cents per 1,000.
Cost of boxes for shipping in America	15 to 25 cents per 1,000.
Cost of freight from Europe to America	40 to 50 cents per 1,000.

In analyzing this table it must be stated that the cost of packages for ocean shipments is high, owing to the greater strength and solidity necessary to undergo the long shipment. The freight charges by steamer are entirely extra, as the charges from the port of entry will about balance the charges on domestic stock from nurseryman to planter.

Besides the above monetary considerations one must take into account the following factors, which should have much weight in deciding whether or not imported stock is to be used:

(1) The relative excellence of the two kinds of stock. While it is generally true that imported stock is as good or better than most American stock, it should not be better, as it has been shown that just as large and good stock can easily be raised even in the Adirondacks (Pettis, 1910), where the growing season is very short. The writer knows from personal observation that the finest stock can be raised where the growing season is longer.

(2) The risk of the stock being damaged by the ocean voyage. This is by no means an insignificant danger, as is shown by the condition of various shipments every spring. Many European nurserymen do not pack coniferous stock in the best manner; only a few, in fact, being known who send shipments with uniform success. During the spring of 1910 several large shipments were received so badly molded and dried out that they were nearly worthless. Beside the actual damage must be considered the disappointment of the planter, as it is impossible to secure a second lot of stock in time to use it that season.

(3) The importation of insect and fungous pests, which may soon cause far more loss than the entire value of the imported stock. Moreover, they are almost certain to cause the owner greater loss than his neighbors, since they usually are worse in the vicinity where they first break loose. American nurserymen are realizing that they must grow coniferous stock in larger quantities and at moderate prices. There is quite a universal movement in enlarging the output of these species throughout the country, several firms already turning them out by the million, one having also reduced its prices to such a point that they compare very favorably with European prices.

WHY PORT INSPECTION IS INEFFICIENT.

Cronartium ribicola vegetates in the bark tissues of pine for a number of months before any external signs of its presence are visible. This period of incubation is of uncertain length, but apparently varies from about one year to several years. During this time no inspection, however thorough, can detect the disease. A very good example of this is afforded in connection with certain trees imported in 1908 when two years old which the writer carefully examined in 1908 for this disease without finding the slightest signs of it. In 1909 1 per cent were affected. The same thing has happened in others imported in 1909 when 2 years old. They now have the disease. Dock inspection can not detect affected trees except such as already have developed swellings or fruiting bodies. This is true of any single inspection which can be made. Repeated inspections are absolutely necessary in order to make sure that imported stock is free from this disease. Such repeated inspections soon cost more than the value of the seedlings.

WHY NO NURSERY CAN BE GIVEN A CLEAN BILL OF HEALTH.

The giving of a clean bill of health to a nursery has the same difficulties as inspection. An inspecting pathologist would have to know intimately the entire neighborhood surrounding the nursery; he would have to watch the nursery for at least two years, and in most cases longer, in order to be able to certify that this disease was not present. A single brief trip to Europe by an American pathologist could not possibly give conclusive evidence regarding a single European nursery, to say nothing of dozens. The proposition would involve the residence of a pathologist in Europe who would spend most of his time in examining nurseries. Even this could not be conclusive unless the entire life history of the imported seedlings was known to this man.

PREVENTION ALWAYS EASIER AND CHEAPER THAN CURE.

The essential feature of all plant pathological work which has to do with combating disease is prevention rather than cure. This is necessarily so, since the nature of plants renders curative measures of very doubtful efficacy as a rule. If the disease can be prevented the work is much more successful and satisfactory than when endeavors are made to stop a serious outbreak. This is preeminently the case with America and the white-pine blister rust. Comparatively small effort will keep it out, while no effort likely ever to be exerted will stop it after it once becomes established here. The sooner the situation is taken in hand the cheaper it can be done. The situation in Europe is steadily growing worse so far as we are able to judge, and this would be the case in America should this disease obtain a secure foothold. The disease has been eradicated once in America, and it can be done again if the recommendations herein made are carried out.

THE WORK OF ERADICATION MUST BE DONE BY THE STATES.

There are no Federal laws in this country which apply to plant diseases. Hence the United States Department of Agriculture is without power to prohibit the importation of white-pine stock, even if known to be diseased. This places all responsibility on the various State organizations, as most of the States have laws of some sort for the regulation of serious plant diseases. Those which have none must in self-defense pass them at once. The Office of Investigations in Forest Pathology of the Bureau of Plant Industry is ready to do all in its power, and to that end will instruct inspectors, make examination of material sent to it, and advise as to the best methods of combating the disease in specific instances. It has a limited supply of colored charts of this fungus (Von Tubeuf, 1905 *c*) which will be sent to applicants.

CAUTION TO GENERAL NURSERYMEN.

Nurserymen who handle and grow any of the species of currants and gooseberries will do well to keep *Cronartium ribicola* in mind at all times. Its three appearances on Ribes in this country are utterly inexplicable, and two of them may have been the result of importing new stock and varieties. Notwithstanding that it is supposed to attack only the leaf blades of Ribes, there is the possibility of its infecting buds or young wood and thus being carried on dormant bushes or cuttings. There is constant danger when Ribes and *Pinus strobus* or any other five-leaved pine is imported from Europe, and the general nurseryman will but follow the dictates of simple prudence if he

keeps Ribes well separated in his grounds from the five-leaved pines of any species and if he inspects his currants and gooseberries once in a while every summer for the fungus. Specimens of diseased leaves should be sent to the State agricultural experiment station or to the Office of Investigations in Forest Pathology of the Bureau of Plant Industry for identification of the fungus infesting them.

REMOVAL OF RIBES.

The cultivated Ribes give little or no trouble in removal, as they are all species which grow in definite clumps and can be uprooted quite easily. The wild species, however, vary much in their characters; most of them grow in more or less definite clumps, several feet in height, so that they are quite easily located by the inspector. The spiny species, such as *Ribes cynosbati,* are very difficult to handle and the person removing them should have a heavy pair of leather gloves. *Ribes prostratum,* the skunk currant, offers other difficulties; it grows in swampy locations and spreads by underground stems which creep under the dead leaves and débris and show only their tips, which rise only to a height of 6 to 18 inches. It requires close inspection to detect this species even where it is quite plentiful. It usually does not grow in heavy woods but in rather open forest or open swampy places. It requires the utmost care to succeed in removing every piece of the spreading root stocks. A small bit left will suffice to renew the plant; hence it is imperative that it be entirely removed. In the summer of 1910 it has been found that new plants occupy the ground from which Ribes were removed the previous season. The creeping species may be expected in nearly all parts of New England and in elevated parts of New York, the Lake States, and southward in the Appalachians to North Carolina. The upright species may be found almost anywhere throughout the country where shrubbery of any kind is found growing wild.

THE PRESENT SYSTEM OF HANDLING IMPORTATIONS UNRELIABLE.

The present system of handling imported stock for insect inspection may be briefly outlined as follows: Customs house officers send to the Entomologist of the United States Department of Agriculture a daily report of importations of nursery stock, covering the following items, as well as others: (1) Consignor, (2) consignee, (3) kind of stock, and (4) number of packages. Each of these statements may be either indefinite or erroneous. (1) The name of a European agent may be given as the consignor, whereas the information wanted is the name of the nursery where the stock originated. (2) The name given as the consignee is very often that of an agent or broker, and does

not show the destination of the stock. (3) The description of the stock may be so worded that practically no information is given. (4) The specification as to the number of packages may be indefinite as to the number of trees. This should be given in round numbers at least.

Even with these statements in hand it is impossible in many cases to tell what shipments contain white pine or Ribes, from what nursery they come, or to whom and where they are going, all of which information is necessary in order to decide whether inspection is needed and to notify the proper inspection authorities when necessary.

Besides the notice from the customs house, the railroads send in notices of lots forwarded by them. Upon receipt of these statements the Entomologist of the Department of Agriculture informs the inspectors of each State about the stock needing inspection which is on its way to that State. This procedure works fairly well for insect pests, but could be much improved. For the white-pine blister rust it is very defective and results in much useless expenditure of money and time in tracing uncertain lots of stock. The past spring the Office of Investigations in Forest Pathology sent notices to the State inspectors concerning all suspicious lots of trees, but we are far from sure that all or even the greater part of the importations were known. A very radical change is needed to make the service as efficient as it should be.

At present Federal pathologists have absolutely no power with regard to diseased stock in any State; hence State officials must handle the inspection and take such measures as their laws provide. The States vary much in the efficiency of their inspection laws and in the execution of those laws, the protection afforded ranging from practically none to nearly perfect. Even in the best protected States it is not uncommon to find lots of stock which have gotten into the State without the inspector having been informed. In the other States it is very common for such lots to gain entry entirely unknown to the proper authorities. Besides all this the State laws apply only to stock raised within the State or shipped from outside the State to some point within and then unpacked and planted out. That is, any amount of stock may be imported and shipped again to other States without being required to pass any inspection at all. In nearly all States the imported stock may even be repacked into smaller lots before being reshipped. The next State receiving such stock receives it under the assumption that it was raised in the former State, and it is inspected or not, as the laws of the latter and its inspection service may determine.

As previously stated in this bulletin, it is quite a general custom among nurserymen handling ornamental stock to import their supply

of 1-year-old conifers. The cost is small and this procedure saves annoyance and the bother of handling seed beds of their own. It is also not uncommon for these nurserymen to buy older stock and fill their orders with it. The ornamental trade usually calls for small lots of each species used, thus giving a maximum distribution to diseased trees. In this way a lot of 50,000 trees might very easily be sent to hundreds of different places throughout the country. In these cases it is impossible to trace all such trees to their final destination, and it is exceedingly difficult to learn of the importations so that they can be inspected before being distributed to the planters.

Besides the ornamental nurseryman, an increasingly large number of private growers import directly for their own use in lots of five thousand to several hundred thousand. These trees are especially hard to locate.

A third class of importers are the brokers who handle only large lots; these import all their stock and sell it to nurserymen or to private individuals in lots ranging from one thousand to several hundred thousand. The brokers' transactions in many cases do not come under the State laws, and considerable of their stock is never inspected. For instance, a lot of trees is received by a New York broker at the Hoboken wharves; he immediately sends some of it to a Middle Atlantic State. That stock is not inspected by the New York inspectors, as its destination is another State, and it is not unpacked in New York. When received at its destination the shipment is either planted out in a nursery or is again split up and forwarded to still other localities, partly in other States, where it finally is planted out. In each shipment of the lot from one State to another no inspection is made by the State from which the shipment is made, and if the laws or inspections are defective for any reason in the State receiving the shipment the diseased trees may pass the entire gamut without ever passing under an inspector's eye. Many such cases occur every spring.

LEGISLATION AGAINST PLANT DISEASES.

Owing to the impracticability of inspection to detect the blister rust, some other method of handling it is necessary. The difficulties in giving foreign nurseries a clean bill of health seem to preclude this procedure. Whether foreign authorities can be induced to take up the supervision of their nurseries and give certificates which are reliable is very questionable and at the best will take much time. Most of the foreign inspections for insects are known to be superficial and inefficient at present. The only measure left available seems to be the prohibition of the importation of white pine and Ribes, at least temporarily and from certain sections.

Such prohibition of the importation of special plants because of dangerous fungous diseases is by no means a rarity in other countries

and is in full operation for diseases of animals in this country. England[a] has faced the same sort of exigency in the case of the American gooseberry mildew and has recently prohibited the importation of gooseberry and currant plants. This action probably was taken too late, as the disease had become well established already. Similar action against the same fungous disease has been taken by Ireland,[b] Sweden,[c] and Finland,[d] and such action is more than likely to be taken by a number of other European countries which have discovered the fungus present within their boundaries.

The white-pine blister rust is not the only serious foreign fungous disease which threatens shortly to become established in America. The wart disease of the potato caused by *Chrysophlyctis endobiotica* Schilbersky is prevalent in a number of European countries and has caused much alarm there because of its destructive attacks and its ability to survive for a number of years in the soil. This disease is already present in North America, having been recently discovered in Newfoundland. Seed potatoes have recently been shipped from Newfoundland to this country, but so far as known the disease is not yet present here. It is already a proscribed disease in Canada, Ireland, Great Britain, Sweden, and the Transvaal.[e]

Some sort of prohibition of the importation of plants is in force in Germany,[f] Crete,[g] Portugal,[h] Turkey,[i] Argentine Republic,[j] Tunis,[k] Cape Colony,[l] Transvaal,[m] Rhodesia,[n] Natal,[o] South Africa,[p] Orange River Colony,[q] Tasmania,[r] New Zealand,[s] New South Wales,[t] Victoria,[u] Queensland,[v] South Australia,[w] West Australia,[x] Straits Settlements,[y] Austria-Hungary, Belgium, France, Netherlands, and Switzerland,[z] practically all having special reference to importations from the United States because of peach yellows, black-knot, and pear-blight, as well as insect pests.

Canada[aa] has already taken action against the white-pine blister rust, together with other serious diseases, the principal features of

---

[a] Journal of the Board of Agriculture, London, vol. 14, 1907, p. 564, and vol. 15, 1908, pp. 304–305.

[b] Idem, vol. 15, 1908, p. 548.

[c] Eriksson, J. Journal of the Royal Horticultural Society, London, vol. 31, 1906, pp. 138–141.

[d] Salmon, E. S. Idem, pp. 128–137.

[e] Orton, W. A., and Field, Ethel C. Wart disease of the potato. Circular 50, Bureau of Plant Industry, U. S. Dept. of Agriculture, 1910, pp. 1–11.

[f] Journal of the Board of Agriculture, London, vol. 10, 1903, pp. 255–256.

[g] Idem, vol. 13, 1907, p. 760.

[h] Idem, vol. 14, 1908, p. 630.

[i] Idem, vol. 14, 1907, p. 311.

[j] Idem, vol. 13, 1907, p. 632; vol. 14, 1907, p. 330.

[k] Idem, vol. 11, 1904, p. 184.

the law being as follows: (1) Entry must be made through certain ports and at certain specified seasons; (2) nursery stock (in the widest sense) infested with specified insects or fungi is forbidden entry; (3) notice of shipment must be given the Minister of Agriculture by the consignor, by the transportation companies, and by customhouse brokers and other persons importing such stock; (4) certain stock may proceed to destination and then be inspected, but must not be unpacked except in the presence of an inspector; (5) diseased stock will be destroyed, together with packages and packing; (6) compensation of two-thirds the total value of the destroyed stock, packages, etc., shall be granted upon recommendation of the Minister; (7) it is illegal to dispose of diseased stock in any way, and the owner must send the Minister of Agriculture samples and a notice of the diseased condition immediately after the discovery of the disease; and (8) the importation of certain insects and fungi may be permitted for scientific purposes only.

There is every precedent in favor of action by the United States similar to that taken in Canada, and this seems to be the only available method of keeping the disease out of the country. Somerville (1909), of England, says the following concerning this matter:

> But if, by good chance, the disease has not yet reached America, the Governments of Canada and the United States ought to take a step that should have been taken earlier, namely, prohibit absolutely the importation of any plant of five-leaved pines or of any species of Ribes. Careful inspection and fumigation at the port of entry are

---

[l] Lounsbury, C. P. The Agricultural Journal of the Cape of Good Hope, vol. 24, 1904, pp. 702–707.

[m] Journal of the Board of Agriculture, London, vol. 14, 1908, pp. 742–743.

[n] Idem, vol. 13, 1906, pp. 433–434.

[o] Idem, vol. 13, 1906, p. 499.

[p] Butler, F. D. Agricultural Gazette of New South Wales, vol. 18, 1907, pp. 629–631.

[q] Idem, vol. 18, 1907, p. 631.

[r] Idem, vol. 18, 1907, pp. 627–628.

[s] Journal of the Board of Agriculture, London, vol. 11, 1904, p. 306; vol. 13, 1906, p. 185.

[t] Butler, F. D. Op. cit., vol. 18, 1907, pp. 628–629.

[u] Idem, vol. 18, 1907, pp. 620–623.

[v] Idem, vol. 18, 1907, p. 623.

[w] Idem, vol. 18, 1907, pp. 623–625.

[x] Idem, vol. 18, 1907, pp. 625–627; Journal of the Board of Agriculture, London, vol. 13, 1906, p. 177.

[y] Lemon, A. H. Agricultural Bulletin, Straits and Federated Malay States, vol. 7, 1908, pp. 613–614.

[z] Howard, L. O. Circular 41, Division of Entomology, U. S. Dept. of Agriculture, entitled "Regulations of Foreign Governments Regarding the Importation of American Plants, Trees, and Fruits," 1900, pp. 1–4.

[aa] Memorandum, Department of Customs, Canada, May 11, 1910.

of no avail, for the fungus may be present for a year in the stems of the pines before showing itself on the surface as blisters.

Such authority given to the Secretary of Agriculture could be used effectively to compel nurseries to clean out the disease and would prevent their dumping infected stock into America, as has been done in the past and is even now being done.

While the various States are being forced to enact laws, which at best will handle this disease imperfectly, the disease will continue to be shipped throughout the country and will have every chance to obtain a secure foothold long before such laws become effective. Ignorance of the true state of affairs and indifference on the part of legislators usually give a new disease ample opportunity to become established. This is apparently true of the gooseberry mildew in Ireland and England and is more than likely to be true of the white-pine blister rust in this country unless preventive measures are taken by the National Government at once.

If this disease becomes established no effort adequate to handle it is ever likely to be exerted. A comparatively small expense at present will clean it entirely out of the country, while it can be easily kept out by a quarantine system. The annual expense of preventing further importations will not be as great as the amount already expended in trying to rid ourselves of a single year's importation of it. If the importation of white-pine nursery stock can not be absolutely prohibited, then the system of importation should be by permits, so that the Secretary of Agriculture will know of all shipments which enter the country.[a]

SUMMARY.

The reforestation movement, which is constantly and rapidly gaining in volume, has created a market for a considerable amount of young white-pine stock. The producing capacity of American nurseries has not kept pace with this demand. The prices for American trees are higher than European prices for the same grade of stock, this being caused partly by the lower cost of labor in Europe and partly by inexperienced management in America. White-pine nursery stock has been imported from Europe for years in limited quantities, but within the last five years the amount has increased very rapidly in spite of the obvious danger of introducing into this country some destructive insect or fungous pest.

Cronartium ribicola was discovered by Dietrich in 1855 in Russia and named by him. Klebahn in 1887 divided the pine-bark inhabiting *Peridermium pini* into three distinct species; i. e., *P. pini*, *P.*

[a] See the Yearbook of the Department of Agriculture for 1909, p. 44.

cornui, and *P. strobi*, the latter being the form occurring on *Pinus strobus*. A little later Klebahn proved that *Peridermium strobi* on white pine is only one stage of *Cronartium ribicola*, which occurs on currant and gooseberry leaves. Other investigators corroborated his discovery. Still later it was proved that the Peridermia of *Pinus cembra*, *Pinus lambertiana*, and *Pinus monticola* are identical with *P. strobi* and are also stages of *Cronartium ribicola*.

The blister-rust fungus has been found to be present in Norway, Sweden, Finland, Russia, Siberia, Japan, Austria-Hungary, Italy, Switzerland, Germany, Denmark, France, Belgium, Holland, Scotland, and England. (See fig. 1.) In America it has been introduced into Kansas, New York, Vermont, New Hampshire, Massachusetts, Connecticut, Pennsylvania, Indiana, and Ohio, and it may be present in Minnesota and in Ontario, Canada. It is known to have been shipped to 230 different localities in North America.

Economically, the Cronartium stage of this fungus is of little importance, as it does not usually kill affected Ribes bushes. Its chief importance is due to its serving to spread the disease to pines. The Peridermium stage on pines causes much damage. It kills young trees and young branches on large trees, even killing old trees by depriving them of the small branches. The fungus can attack only branches or stems that are about 20 years old or younger. Cases are known where trees 100 years old have been killed by it, and many cases are known where trees from 10 years to 50 years old have been rendered unsightly and utterly spoiled for park purposes. In the forest the trees are stunted and sooner or later break over at the attacked place if they survive until they are 25 or 30 years old. In nurseries the greatest damage is done, entire beds and even the entire stock of nurseries being rendered unsalable. In a considerable number of instances the culture of the white pine has been abandoned because of this disease. Definite mention has been found of this disease occurring in the following nurseries in Germany at some time: Späth, Berlin, H. C. A. Helleman, Lilienthal, Metz & Co., Steglitz, and H. H. Pein, Halstenbek. This does not necessarily indicate that the disease is now present in these nurseries. Diseased stock has been received in America from Levavasseur & Fils, Ussy, E. T. Dickinson, Chatenay, and Barbier & Co., Orleans, France. But the firm of J. Heins Söhne, Halstenbek, Germany, has sent far the largest quantity. The disease has been further mentioned as occurring in nurseries near Berlin, Muskau, Eberswalde, Amelsbüren, Delmenhorst, Tharandt, Hamburg, and Mühlenbek, Germany; Paris, France; Stockholm, Sweden; and St. Petersburg, Russia. In three of these localities the disease occurred in nurseries of royal forestry institutions.

The life history of *Cronartium ribicola* is quite complicated. It may be very briefly stated as follows: The sporidia formed on the leaves of currants and gooseberries are blown about for some distance in the vicinity of the affected bushes. They alight on all parts of the white pines which happen to be near, and those which stick to the young bark germinate and the germ tube penetrates the bark. After it has once gotten within the bark tissues it is impossible to kill the fungus without killing the infected part of the host. Here it develops slowly for ten months or more, when the bark becomes raised in small blister-like patches which are more or less translucent. Finally small, round drops of a sticky, sweet, colorless fluid are exuded through small openings in the bark (fig. 3). These drops are full of tiny spores, called pycnospores. They are followed in the succeeding April, May, and early June by the Peridermium spores, which are produced in whitish, blistery elevations, which break open and set the orange-colored spores free (Pl. I, *A*; Pl. II, fig. 2). The Peridermium spores, in turn, are blown to plants of currants and gooseberries, where they germinate and infect the leaves. Here also two distinct forms of spores are produced; i. e., yellow spores, breaking out in tiny round pustules on the under side of the leaves (Pl. I, *B* and *C*), and later tendril-like threads, yellow and later turning brown, bearing large compound spores (Pl. I, *D*). The two forms are known, respectively, as uredospores and teleutospores. When the teleutospores germinate they immediately produce a third form of spore, known as sporidia, which is capable of infecting pines. The Peridermium spores, the pycnospores, and the uredospores can not infect pines; the first and last can infect currants and gooseberries. That is, it is necessary for both pines and Ribes to be near enough together to infect each other in order to have the disease reproduce itself. The fungus lives and fruits year after year on the pine until the tree dies, but on Ribes it falls with the leaves and has to reinfect the bush the next season.

The Peridermium stage is known to attack *Pinus strobus*, *P. cembra*, *P. monticola*, *P. excelsa*, and *P. lambertiana*, all five-leaved pines. It seems probable that it may also occur upon any or all the other five-leaved species of pine. These are *Pinus peuce*, *P. ayacahuite*, *P. strobiformis*, *P. scipioniformis*, *P. pentaphylla*, *P. parviflora*, *P. pumila*, *P. flexilis*, *P. albicaulis*, *P. koraiensis*, *P. armandii*, *P. balfouriana*, and *P. aristata*. The Cronartium stage has been found upon twenty-six species of Ribes, and apparently no species is entirely immune. There are at least twice this number of species of Ribes in the world, and so far as known they are all susceptible to the attacks of *Cronartium ribicola*. So far as our knowledge goes at present the fungus might spread throughout the North Temperate

Zone, since each of these two groups of plants within the combined ranges of its species includes nearly all this territory.

Considering the past record of this fungus, as well as that of others when introduced into new climates and upon new hosts, we may expect *Cronartium ribicola* to be more destructive in America, should it once become established, than it has already been in Europe. Moreover, it would finally affect not only the white-pine belt but also the mountain region west of the Mississippi River as well.

It is proposed to call the Cronartium stage of this fungus the "currant felt rust" and the Peridermium stage the "white-pine blister rust."

Affected young white pines are peculiarly stunted in appearance, the top having a thick, bunchy appearance (Pl. II); the new growth is usually shorter than normal (Pl. II, fig. 2); the leaves may be somewhat yellowed; the affected stem is thickened in a spindle-shaped swelling in most cases (Pl. I, *A*; figs. 3 and 4), while in others it is swollen the whole length of a year's growth, with irregular bunches at intervals (Pl. II, fig. 2). The long period of incubation renders a dock inspection of no value except in the case of trees which already have the disease well developed.

The situation is well in hand and there need be no undue apprehension if the persons concerned continue to follow up the careful inspection work already under way. The disease has been eradicated once with complete success and there is no reason why it can not be done again.

The diseased stock thus far seen has come from the firm of J. Heins Söhne, of Halstenbek, Germany, with the exception of four lots received from three French firms and which may not have been raised by them. Trees 3, 4, 5, 6, 7, and 10 years old with fruiting bodies of this fungus upon them, or with unmistakable signs of the disease, have been found in America.

Methods of preventing and combating this disease are briefly as follows: Stop importing five-leaved pine and Ribes stock and raise it at home; watch imported Ribes stock during the first season, and preferably the second also; keep five-leaved pines well separated from Ribes if either is imported (a distance of 500 feet is advisable); where the disease is already present all Ribes should be removed from the vicinity of the affected pines to a distance of 500 feet or more; remove and burn all diseased pine trees, making inspections from the last of April to June 10; inspect Ribes from July 1 until late in the fall, removing diseased bushes and burning them; inspect diseased lots of pines the second spring to detect such as may have developed the disease in the meantime; if any are found in the second season's inspection it will be necessary to make a third inspection to make

sure that all diseased trees have been removed; when buying five-leaved pine stock, even in this country, require the seller to guarantee the stock to be free from this disease or else to have been raised in America.

The preference of this parasite for the five-leaved pines is of special significance to America, since these pines are naturally present through the western, northern, and northeastern forests and are planted more or less commonly thoughout the country. The chances for great losses if this fungus should even approximate its past record in Europe are very good. Estimates of possible damage show that such losses would very soon far exceed the total valuation of all coniferous stock ever imported into the country. If this disease becomes established in America the present really important reforestation movement will be unable to survive the addition of this last straw to its already large burden of difficulties. While the monetary cost of imported stock is less than that of American stock, the various items of expense which necessarily are incurred bring the two nearer together than would at first be thought. Moreover, the risks of injury from the long trip, and of importing destructive insect and fungous pests are so great as to deter any but the most venturesome from importing such stock.

The repeated inspection necessary for imported trees soon costs more than the original value of the stock. Under the present system of handling importations it is impossible to know whether diseased stock is being imported or not. Many other countries have laws regulating the importation of certain plants. Only the past spring Canada took measures against the white-pine blister rust, and similar action should be at once taken in this country. Such action should consist of the prohibition of the importation of five-leaved pines and of plants of Ribes. Failing this, it should be such as will keep the Department of Agriculture informed with absolute certainty about each and every such importation that is made; this would be accomplished by the permit system.

BIBLIOGRAPHY.

A bibliography of the blister rust of the white pine follows:

1854. Tulasne, L. R. Second mémoire sur les Urédinées et les Ustilaginées. Annales des Sciences Naturelles, Botanique, ser. 4, vol. 2, p. 189.

Tulasne mentions the occurrence of a Cronartium on Ribes in India.

1856. Dietrich, H. A. Blicke in die Cryptogamenwelt der Ostseeprovinzen. Archiv für die Naturkunde Liv-, Esth-, und Kurlands, ser. 2, vol. 1, p. 287.

First time name was published; no description given; contains notes of occurrence on Ribes and *Pinus strobus* in the Baltic provinces of Russia.

1867. Oersted, A. S. Lövsporeplanterne.

The original has not been seen.

1872. Fischer von Waldheim, A. In Rabenhorst's Fungi Europaei exsiccati, no. 1595. Cited in Hedwigia, vol. 11, p. 182.

A description of the uredo stage of *Cronartium ribicola* is given on the label of the specimen.

1873 *a*. Magnus, P. Hedwigia, vol. 12, p. 52.

Cronartium ribicola was found upon *Ribes aurem* at Kiel, Germany, in 1872.

1873 *b*. ——— Sitzungsberichte der Gesellschaft Naturforschender Freunde zu Berlin, pp. 136–137.

Magnus found *Cronartium ribicola* on Ribes at Stralsund and Kiel, Germany, in 1872; also found in Denmark by Oersted; states that it apparently came from America.

1873. Oersted, A. S. System der Pilze, p. 33.

Bare citation under the name *Cronartium ribis*.

1874. Hartig, R. Wichtige Krankheiten der Waldbäume, p. 70, pl. 4, fig. 7.

Hartig mentions receiving specimens of Peridermium on branches of *Pinus strobus*.

1874 *a*. Magnus, P. Sitzungsberichte der Gesellschaft Naturforschender Freunde zu Berlin, pp. 21–22.

Magnus remarks on the sudden appearance of *Cronartium ribicola* where it was previously unknown.

1874 *b*. ——— Verhandlungen des Botanischen Vereins der Provinz Brandenburg, vol. 16, pp. 58–60.

A brief account of the discovery of *Cronartium ribicola* by Dietrich and its subsequent spread in Europe is given.

1874 *c*. ——— Botanische Zeitung, vol. 32, pp. 330–332.

The occurrence of *Cronartium ribicola* in various places is mentioned.

1874. Rostrup, E. Notiz über Cronartium ribicola. Botanische Zeitung, vol. 32, pp. 79–80.

A letter from Rostrup saying that this fungus was mentioned in a list of plants available for exchange among the members of the Botanical Society of Copenhagen in the spring of 1871.

1875. Schroeter, J. Ueber einige amerikanische Uredineen. Hedwigia, vol. 14, p. 167.

Schroeter says that *Cronartium ribicola* has never been found by Schweinitz or received by Berkeley from America and that it can not be an American fungus.

1876. Hisinger, Edward. Peridermium pini (Willd.) Pers. a corticola dödande Pinus strobus. Botaniska Notiser, p. 75.

Hisinger found *Cronartium ribicola* in 1869 killing 30-year-old white pines.

1876 *a*. Sorokin, N. Notiz über Verbreitung des Cronartium. Hedwigia, vol. 15, pp. 84–87.

Cronartium ribicola was found by Regel and Woronin at St. Petersburg, Russia; also by Stefankowo near Moscow. Sorokin found stylospores, and Schell found the fungus on Ribes in the Urals.

1876 *b*. ——— Hedwigia, vol. 15, pp. 145–146.

Sorokin found *Cronartium ribicola* on *Ribes aureum* but not on *R. nigrum;* inoculations did not succeed.

1877. Körnicke, F. Mykologische Beiträge. Hedwigia, vol. 16, p. 24.

Körnicke found *Cronartium ribicola* on Ribes near Konigsberg in East Prussia.

1877. Rostrup, E. Om de paa vore träagtige Planter, dog fortrinsvis paa Skovträerne opträdende Uredineer eller Rustsvampe. Tidsskrift for Skovbrug, vol. 2.

The original has not been seen.

1877. Wolff, R. Beitrag zur Kenntniss der Schmarotzerpilze. Landwirtschaftliche Jahrbücher, vol. 6, pp. 723–757.

In this paper on *Peridermium pini* mention is made of its occurrence on *Pinus strobus.*

1878. Arbois de Jubainville, A. d', and Vesque, J. Les maladies des plantes cultivées, pp. 186–187.

Incidental mention of *Cronartium ribicola* on *Pinus strobus* is made.

1878. Winter, G. Die durch Pilze verursachten Krankheiten der Kulturgewächse, pp. 111–114.

Peridermium pini is mentioned as occurring on *Pinus strobus.*

1880 *a*. Thümen, F. von. Beiträge zur Pilz-Flora Sibiriens, IV. Bulletin de la Société Impériale des Naturalistes de Moscou, vol. 55, p. 213.

Cronartium ribicola is mentioned as occurring on *Ribes rubrum* on the Inja River in Siberia.

1880 *b*. ——— Die Blasenrostpilze der Coniferen. Mittheilungen aus dem Forstlichen Versuchswesen Oesterreichs, vol. 2, pp. 310–311.

Peridermium pini is said to occur on the stems of *Pinus strobus* in Denmark, Germany, and Finland.

1880. Winter, G. Verzeichniss der im Gebiete von Koch's Synopsis beobachteten Uredineen und ihrer Nährpflanzen. Hedwigia, vol. 19, p. 55.

Note of the occurrence of *Cronartium ribicola.*

1883. Rostrup, E. Fortsatte Undersögelser over Snyltesvampes Angreb paa Skovtraeer. Tidsskrift for Skovbrug, vol. 6.

The original has not been seen.

1884. Winter, G. In Rabenhorst's Kryptogamen-Flora von Deutschland, Oesterreich, und der Schweiz, vol. 1, p. 236. (Edition 2.)

Winter gives a description of *Cronartium ribicola.*

1885. Oudemans, C. A. J. A. Aanwinsten voor de flora mycologica van Nederland, IX–X. Nederlandsch Kruidkundig Archief, ser. 2, vol. 4, p. 239.

Notes occurrence of *Cronartium ribicola* in Holland.

1886. ——— Contributions à la flore mycologique des Pays-Bas, XI. Nederlandsch Kruidkundig Archief, ser. 2, vol. 4, p. 515.

Note of occurrence of *Cronartium ribicola* in Holland.

1887. Klebahn, H. Beobachtungen und Streitfragen über die Blasenroste. Abhandlungen herausgegeben vom Naturwissenschaftlichen Vereine zu Bremen, vol. 10, pp. 145–155, pl. 1, figs. 5–10, 13, and 14.

Klebahn splits up the old species *Peridermium pini corticolum* into three distinct species, one of which is *P. strobi,* which he distinguishes by its earliness of fruiting and the character of the spores.

1887. Schroeter, J. In Cohn's Kryptogamen-Flora von Schlesien, vol. 3, p. 373.

Gives places of occurrence of *Cronartium ribicola* in Silesia.

1888 *a*. Klebahn, H. Ueber den Rindenrost der Weymouthskiefer Peridermium (Aecidium) strobi. Botaniska Notiser, pp. 229–230.

A general statement of the hetercœcism of *Cronartium ribicola*.

1888 *b*. ——— Weitere Beobachtungen über die Blasenroste der Kiefern. Berichte der Deutschen Botanischen Gesellschaft, vol. 6, pp. xlv–lv.

One of the best articles on *Cronartium ribicola;* general account of its life history and a description of the disease caused by it on the white pine.

1888. Nordstedt, O. Botaniska Notiser, p. 236.

Note of the occurrence of *Cronartium ribicola* in Sweden.

1888. Toni, J. B. de. In Saccardo's Sylloge fungorum, vol. 7, pp. 598–599, 837.

De Toni gives a scientific description of *Cronartium ribicola* in both stages.

1889. Klebahn, H. Bemerkung über den Weymouthskieferrost. Abhandlungen herausgegeben vom Naturwissenschaftlichen Vereine zu Bremen, vol. 10, pp. 427–428.

Klebahn announces the discovery of the alternate stage of the white-pine rust by successful inoculations on Ribes; also mentions a number of places in Germany where the fungus has been found.

1889. Schroeter, J. In Cohn's Kryptogamen-Flora von Schlesien, vol. 3, p. 373.

Schroeter gives a scientific description of *Cronartium ribicola* and notes its occurrence in Silesia.

1889. Ward, H. Marshall. Timber and some of its diseases, p. 258.

Ward mentions *Peridermium pini* as occurring on *Pinus strobus.*

1890. Eriksson, J. Om några sjukdomar å odlade växter. Kungliga Landtbruks-Akademiens Handlingar och Tidskrift, vol. 29, pp. 223–225.

An account of *Cronartium ribicola* in Sweden and the damage done.

1890 *a*. Klebahn, H. Ueber die Formen und den Wirtwechsel der Blasenroste der Kiefern. Berichte der Deutschen Botanischen Gesellschaft, vol. 8, pp. (59)–(70).

A statement of the knowledge of the Peridermiums formerly included in the old species *P. pini.*

1890 *b*. ——— Neue Untersuchungen und Beobachtungen über die Blasenroste der Kiefern. Hedwigia, vol. 29, pp. 27–35.

Klebahn describes *Peridermium 'pini, P. cornui,* and *P. strobi;* also gives the results of inoculations with the latter upon Ribes, spores from *Pinus lambertiana* being used successfully; mentions finding æcidiospores on April 16 and says that a tree which bore spermogonia in 1888 had æcidia in 1889.

1890. Poirault, G. Les Urédinées et leurs plantes nouricières. Journal de Botantique, vol. 4, pp. 249, 342.

Incidental mention of *Cronartium ribicola.*

1890 *a*. Rostrup, E. Det förste halve Hundrede af vaertskiftende Rustsvampe. Videnskabelige Meddelelser fra den Naturhistoriske Forening i Kjöbenhavn for Aaret 1889, pp. 242, 250.

Incidental mention of *Peridermium strobi,* with change of name to *P. klebahni.*

1890 *b*. Rostrup, E. Undersögelser over Snyltesvampes Angreb paa Skovtraeer 1883–1888. Tidsskrift for Skovbrug, vol. 12.

Original not seen.

1890. Wettstein, R. von. Ueber Ergebnisse von Culturversuchen mit heteröcischen Uredineen. Verhandlungen der Kaiserlich-Königlichen Zoologisch-Botanischen Gesellschaft in Wien, vol. 40, p. 44.

Note on inoculations completely corroborating Klebahn's statements as to the identity of *Peridermium strobi* and *Cronartium ribicola*.

1891. Comes, O. Crittogamia agraria, vol. 1, p. 121.

Comes barely mentions *Cronartium ribicola*.

1891. Dietel, P. Ueber die Fortschritte der Kenntnis von den Rostpilzen in den letzten zehn Jahren. Botanisches Centralblatt, vol. 47, p. 18.

Incidental mention of *Cronartium ribicola*.

1891. Gobi, C., and Tranzschel, W. Beiträge zur Pilzflora, Russlands. (German résumé.) Scripta Botanica Horti Universitatis Imperialis Petropolitanae, vol. 3, pp. 99–100, 121. (In Russian.)

The occurrence of *Cronartium ribicola* in various parts of Russia is noted.

1891. Hartig, R. Ueber die Klebahn'sche Abhandlung über die Formen des Peridermium pini. Botanisches Centralblatt, vol. 46, pp. 18–19.

A mere note.

1891 *a*. Magnus, P. Ueber den Rost der Weymouth-Kiefern, Pinus strobus L. Gartenflora, vol. 40, pp. 452–453.

An account of the white-pine blister rust as observed in Germany; Magnus mentions finding uredospores on May 26.

1891 *b*. ——— Ueber den Rost der Weymouth-Kiefern (Pinus strobus L.). Naturwissenschaftliche Rundschau, vol. 6, pp. 477–478.

A general account of the white-pine blister rust, with a statement of the damage sustained in different places in Germany.

1891. Sorauer, P. Peridermium strobi Kleb. Zeitschrift für Pflanzenkrankheiten, vol. 1, pp. 183, 366–367.

Results of inoculations on various species of Ribes are presented.

1892. (Anonymous.) Weymouth pine disease. Gardeners' Chronicle, ser. 3, vol. 11, p. 736.

The writer erroneously calls the fungus *Peridermium pini* and says that the alternate stage is probably on some composite.

1892. Hartig, R. Ueber die bisherigen Ergebnisse der Anbauversuche mit ausländischen Holzarten in den bayerischen Staatswaldungen. Forstlich-Naturwissenschaftliche Zeitschrift, vol. 1, p. 443.

1892 *a*. Klebahn, H. Kulturversuche mit heteröcischen Uredineen. Zeitschrift für Pflanzenkrankheiten, vol. 2, pp. 332–334.

Summary of inoculations with spores of *Peridermium strobi* upon various species of Ribes by himself and previous authors.

1892 *b*. ——— Weymouth pine fungus. Gardeners' Chronicle, ser. 3, vol. 12, p. 133, figs. 22–23.

Klebahn correctly names the fungus and says that Plowright has just discovered the Cronartium stage in England for the first time.

1892. Ludwig, Friedrich. Lehrbuch der niederen Kryptogamen, p. 469.

Cronartium ribicola is barely mentioned.

1892. Oudemans, C. A. J. A. Révision des champignons dans les Pays-Bas, vol. 1, pp. 511, 584–585.

Note of occurrence of *Cronartium ribicola* in Holland.

1892 *a*. Plowright, Charles B. Fungus on Weymouth pine and on currants. Gardeners' Chronicle, ser. 3, vol. 12, p. 44.

Specimens submitted to Klebahn were pronounced to be *Peridermium strobi*.

1892 *b*. Plowright, Charles B. Cronartium ribicola. Gardeners' Chronicle, ser. 3, vol. 12, pp. 137, 501.

Plowright found this for the first time in England on July 3, 1892. He later found the Peridermium stage on white pines near rusted currant bushes.

1892. Schwarz, Frank. Forstliche botanik, p. 222.

Brief statement regarding the white-pine rust.

1892. Ward, H. Marshall. The diseases of conifers. Journal of the Royal Horticultural Society, vol. 14, pp. 134–136.

Follows Klebahn in considering *Peridermium strobi* a distinct species.

1893. Frank, A. B., and Sorauer, P. Jahrbuch der Deutschen Landwirtschafts-Gesellschaft, vol. 8, pp. (430) and (441).

Note of occurrence of *Cronartium ribicola* near Bremen.

1893 *a*. Klebahn, H. Kulturversuche mit heteröcischen Uredineen. Forstlich-Naturwissenschaftliche Zeitschrift, vol. 2, pp. 69–72.

Klebahn says that *Ribes grossularia* is immune to *Cronartium ribicola* but when grafted on *R. aurem* it becomes susceptible.

1893 *b*. ——— Zur Kenntnis der Schmarotzer-Pilze Bremens und Nordwestdeutschlands. Abhandlungen herausgegeben vom Naturwissenschaftlichen Vereine zu Bremen, vol. 12, pp. 372–373.

Klebahn says that spermogonia of *Peridermium strobi* occur similarly to those of *P. pini* on *Pinus sylvestris*.

1893. Nilsson, A. Forstligt botaniska undersökningar i sydöstra Nerike, 1892. Tidsskrift for Skogshushållning, p. 65.

Note of occurrence of *Cronartium ribicola* in Sweden on Ribes, but Nilsson says that white pine was absent for at least three-fourths of a mile.

1893. Plowright, C. B. Peridermium strobi. Gardeners' Chronicle, ser. 3, vol. 13, p. 425.

Plowright found the fungus on white pine near the diseased Ribes bushes which he had previously found.

1893. Sorauer, P. Jahrbuch der Deutschen Landwirtschafts-Gesellschaft, vol. 8, p. 440.

Found *Peridermium strobi* on white pine but not on *Pinus cembra*.

1894. Hartig, R. Textbook of the diseases of trees, pp. 173–175. (Translated by Somerville, William, and Ward, H. Marshall.)

Brief mention of the white-pine blister rust.

1894. Tranzschel, W. Sitzungsbericht der Naturforscher-Gesellschaft zu St. Petersburg, vol. 21, p. 22. (In Russian; the original has not been seen.)

1895. Eriksson, J. Rostsjukdon a Weymouthstallen. Svenska Trädgårdsföreningens Tidskrift, p. 88.

The original has not been seen.

1895 *a*. Klebahn, H. Kulturversuche mit heteröcischen Rostpilzen, III. Zeitschrift für Pflanzenkrankheiten, vol. 5, pp. 73–74.

Successfully inoculated *Cronartium ribicola* on *Ribes grossularia* when the latter was grafted on *R. aureum*.

1895 *b*. ——— Kulturversuche mit heteröcischen Rostpilzen, IV. Zeitschrift für Pflanzenkrankheiten, vol. 5, p. 260.

Klebahn found that the spermogonia of *Cronartium ribicola* are formed the summer after infection takes place, while the æcidia are produced the second summer.

1895. Prillieux, Ed. Maladies des plantes agricoles, vol. 1, pp. 275–276.

A brief statement of the heteroecism of *Cronartium ribicola*.

1895. Rostrup, E. Mykologiske Meddelelser, V. Botanisk Tidsskrift, vol. 19, pp. 215–216.

Rostrup successfully inoculated Ribes with spores from *Pinus strobus*.

1895. Schøyen, W. M. Beretning om Skadeinsekter og Plantesygdomme i 1894, p. 34.

Found *Cronartium ribicola* upon *Pinus strobus;* made successful inoculations upon Ribes.

1895. Tubeuf, C. von. Pflanzenkrankheiten durch kryptogame Parasiten verursacht, p. 395.

A good general account of the white-pine blister rust.

1896. Blytt, Axel. Bidrag til Kundskaben om Norges Soparter. Forhandlinger i Videnskabs-Selskabet i Christiania, p. 70.

Note of occurrence of *Cronartium ribicola* in Norway.

1896 *a*. Eriksson, J. Einige Beobachtungen über den stammbewohnenden Kiefernblasenrost, seine Natur und Erscheinungsweise. Centralblatt für Bakteriologie, Parasitenkunde und Infektionskrankheiten, pt. 2, vol. 2, pp. 377–394.

A good general account of *Cronartium ribicola* and its life history with methods of treatment.

1896 *b*. ——— Några iakttagelser rörande blåsrosten å tallstammar dess natur och förekomstätt. Kungliga Landtbruks-Akademiens Handlingar och Tidskrift, vol. 35, pp. 240–258.

Practically the same as the preceding work.

1896. Frank, A. B. Die Krankheiten der Pflanzen, vol. 2, p. 186. (2d ed.)

A brief statement of heterœcism of *Cronartium ribicola*.

1896. Schøyen, W. M. Beretning om Skadeinsekter og Plantesygdomme i 1895, p. 28.

Note of occurrence of *Cronartium ribicola* in Sweden.

1897. Brick, C. Beitrag zur Pilzflora des Sachsenwaldes. Verhandlungen des Naturwissenschaftlichen Vereins in Hamburg, ser. 3, vol. 5, p. 28.

Notes the occurrence of the disease upon Ribes and white pine in the forests of Saxony.

1897. Bubák, Franz. Ein Beitrag zur Kenntniss der böhmischen Peronosporeen, Ustilagineen und Uredineen. Verhandlungen der Kaiserlich-Königlichen Zoologisch-Botanischen Gesellschaft in Wien, vol. 47, p. 233.

Note of occurrence of *Cronartium ribicola* in Bohemia.

1897. Frank, A. B. Jahresbericht des Sonderausschusses für Pflanzenschutz, 1896, p. 122. In Arbeiten der Deutschen Landwirtschafts-Gesellschaft.

Note of occurrence of *Cronartium ribicola* in Silesia.

1897 *a*. Klebahn, H. Neuere Beobachtungen über einige Waldschädlinge aus der Gruppe der Rostpilze. Forstlich-Naturwissenschaftliche Zeitschrift, vol. 6, pp. 465–473.

Incidental mention of *Cronartium ribicola*.

1897 *b*. Klebahn, H. Kulturversuche mit heteröcischen Rostpilzen, VI. Zeitschrift für Pflanzenkrankheiten, vol. 7, p. 343.

Inoculated *Pinus strobus*, *Ribes nigrum*, and *Vincetoxicum officinale* with æcidiospores from the first; only the Ribes was infected.

1897. Schøyen, W. M. Beretning om Skadeinsekter og Plantesygdomme i 1896, p. 56.

Note of occurrence of *Cronartium ribicola* in Sweden.

1897 *a*. Tubeuf, C. von. Ueber die Verbreitung von Pflanzenkrankheiten. Die Gefahr der Ausdehnung des Rindenblasenrostes der Weymouthskiefer. Forstlich-Naturwissenschaftliche Zeitschrift, vol. 6, pp. 320–324 and figs. 1–3.

Good general account of the distances to which the white-pine blister rust spores are distributed.

1897 *b*. Tubeuf, C. von. Die Nadelhölzer, p. 38.

Von Tubeuf cautions against growing the two hosts of *Cronartium ribicola* in proximity to each other.

1897. ——— and Smith, W. G. Diseases of plants induced by cryptogamic parasites, p. 382.

Brief account of the life history of *Cronartium ribicola* and of the disease caused by it.

1898 *a*. Fischer, Ed. Beiträge zur Kenntniss der schweizerischen Rostpilze. Bulletin de l'Herbier Boissier, vol. 6, pp. 16–17.

Found *Cronartium ribicola* on *Ribes petraeum* in Switzerland, but no white pines were in the vicinity.

1898 *b*. ——— Beiträge zur Kryptogamenflora der Schweiz, vol. 1, pp. 90–91.

Incidental mention of *Cronartium ribicola*.

1898. Hollrung, M. Jahresbericht über die Neurerungen und Leistungen auf dem Gebiete des Pflanzenschutzes, vol. 1, pp. 4–5.

Official notice to nurserymen regarding growing the alternate hosts of *Cronartium ribicola* together.

1898. Klebahn, H. Ueber den gegenwärtigen Stand der Biologie der Rostpilze. Botanische Zeitung, vol. 56, pt. 2, p. 149.

Incidental mention of *Cronartium ribicola*.

1898. Laurie, James. Gardeners' Chronicle, ser. 3, vol. 23, p. 244.

Describes the blister rust as spreading over all of the trees of *Pinus monticola* at Murthly Castle, Perth, Scotland, but not occurring on the white pine and not noted on Ribes. Trees 60 feet high and less were affected.

1898. Magnus, P. Ueber die Beziehungen zweier auf Stachys auftretenden Puccinien zu einander. Berichte der Deutschen Botanischen Gesellschaft, vol. 16, pp. 384–385.

Incidental mention of *Cronartium ribicola*.

1898–9. Plowright, C. B. On the recent addition to our knowledge of the Uredineæ and Ustilagineæ, with special reference to British species. Transactions, British Mycological Society, 1898–9, p. 103.

1898. Smith, W. G. A dangerous disease of the Weymouth pine. Gardeners' Chronicle, ser. 3, vol. 23, p. 202.

Smith says that *Cronartium ribicola* is being imported from Germany into England on nursery stock; cites specific instances of damage.

1898 *a*. Tubeuf, C. von. Der Rindenblasenrost der Weymouthskiefer, eine Gefahr für Garten und Wald. Praktische Blätter für Pflanzenbau und Pflanzenschutz, vol. 1, pp. 11–13 and figs. 1–3.

A very good popular account of the white-pine blister rust.

1898 *b*. ——— Vernichtung des Weymouthskiefernrostes. Praktische Blätter für Pflanzenbau und Pflanzenschutz, vol. 1, p. 63.

Methods of prevention and treatment of white-pine blister rust are given.

1899. (Anonymous.) Bladder rust of Pinus strobus. Gardeners' Chronicle, ser. 3, vol. 26, pp. 72–73.

Specimens of diseased white pine were sent from England to the Imperial Sanitary Office in Berlin, which said that attention had been repeatedly called to this disease two years before.

1899. Bartholomew, Elam. Kansas Uredineæ. Transactions, Kansas Academy of Science, vol. 16, p. 193.

Note of occurrence of *Uredo confluens* in Kansas (since identified as the uredo stage of *Cronartium ribicola*).

1899. Klebahn, H. Kulturversuche mit heteröcischen Rostpilzen, VII. Zeitschrift für Pflanzenkrankheiten, vol. 9, pp. 16–17.

Klebahn made repeated spermogonial inoculations without result.

1899. Massee, George. Weymouth pine rust. A textbook of plant diseases, pp. 233–234.

A brief general account of the disease on white pine.

1899. Plowright, Charles B. Bladder rust of Pinus strobus. Gardeners' Chronicle, ser. 3, vol. 26, pp. 72–73, 94.

Plowright collected *Cronartium ribicola* at King's Lynn, England, on *Pinus strobus*.

1899. Sorauer, P. Jahresbericht des Sonderausschusses für Pflanzenschutz, 1898, p. 122. In Arbeiten der Deutschen Landwirtschafts-Gesellschaft.

Note of occurrence of *Cronartium ribicola* in Mecklenburg, Germany.

1899. Spalding, V. M., and Fernow, B. E. The white pine. Bulletin 22, Division of Forestry, U. S. Dept. of Agriculture, p. 53.

The white-pine blister rust is mentioned, but it is not stated that it is not present in America.

1899. Speschneff, N. N. Arbeiten des Botanischen Gartens zu Tiflis. (Reviewed in Zeitschrift für Pflanzenkrankheiten, vol. 9, p. 357.)

Note of occurrence of *Cronartium ribicola* in Tiflis. The original has not been seen.

1899. Vanderyst, H. Quelques nouvelles stations d'Ustilaginées et d'Urédinées. Revue Générale Agronomique, vol. 8, p. 61.

Note of occurrence of *Uredo confluens* in Belgium; later identified as *Cronartium ribicola*.

1899. Weiss, J. E. Weymouthskiefern-Blasenrost. (Peridermium strobi.) Praktische Blätter für Pflanzenbau und Pflanzenschutz, vol. 2, pp. 52–53.

Cautions nurserymen against sending out diseased white-pine stock.

1900. Dietel, P. In Engler and Prantl's Die Natürlichen Pflanzenfamilien, vol. 1, pt. 1**, p. 41 and fig. 26.

Scientific description of *Cronartium ribicola*.

1900. Fischer, Ed. Die Rostkrankheiten der forstlich wichtigsten Nadelhölzer nach dem heutigen Stande unserer Kenntnisse. Schweizerische Zeitschrift für das Forstwesen, vol. 51, pp. 192–193.

Says *Cronartium ribicola* is unknown in Switzerland on the white pine, but has been found on *Ribes petraeum*.

1900. Hess, R. Der Forstschutz, vol. 2, pp. 266–267.

Says *Cronartium ribicola* is very destructive to white pine; that stems more than 20 to 25 years old are not attacked; recommends that buyers require nurserymen to give guarantee of health of stock sold.

1900. Iwanoff, K. S. Die im Sommer 1898 bei Petersburg (Russland) beobachteten Krankheiten. Zeitschrift für Pflanzenkrankheiten, vol. 10, p. 99.

Note of occurrence of *Cronartium ribicola* in St. Petersburg, Russia.

1900. Jaap, Otto. Verzeichnis der bei Triglitz in der Prignitz beobachteten Ustilagineen, Uredineen und Erysipheen. Verhandlungen des Botanischen Vereins der Provinz Brandenburg, vol. 42, p. 263.

Note of occurrence of *Cronartium ribicola* in Brandenburg, Germany.

1900. Mayr, Heinrich. Naturwissenschaftliche und forstliche Studien im nordwestlichen Russland. Allgemeine Forst- und Jagd-Zeitung, vol 76, p. 122.

States that the white pine is much less clutivated in Russia than in Germany * * * "the blister rust is unfortunately very frequent."

1900. Nypels, Paul. Le Peridermium du Weymouth. Bulletin de la Société Centrale Forestière de Belgique, vol. 7, pp. 577–579.

The white-pine blister rust has spread rapidly in Belgium during the last few years.

1900 *a*. Vanderyst, H. Quelques nouvelles stations d'Urédinées. Revue Générale Agronomique, vol. 9, p. 155.

Note of occurrence of *Cronartium ribicola* in Belgium.

1900 *b*. Vanderyst, H. Les Urédinées observées en Belgique. Revue Générale Agronomique, vol. 9, p. 364.

Cronartium ribicola was first found in Belgium in 1898 and has since spread rapidly.

1900. Ward, H. Marshall. The diseases of conifers. Veitch's Manual of the Coniferæ, p. 62. (Revised ed.)

Gives a brief account of the blister rust of white pine.

1900. Weiss, J. E. Cronartium ribicolum, der Säulenrost der Johannisbeere und Peridermium strobi, der Weymouthskiefern-Blasenrost. Praktische Blätter für Pflanzenbau und Pflanzenschutz, vol. 3, pp. 75–76.

Weiss recommends buying trees which are four are five years old, as the white-pine blister rust will have shown by that time, if the trees are diseased.

1901. Aderhold, R. Jahresbericht des Sonderausschusses für Pflanzenschutz, 1900, p. 190. In Arbeiten der Deutschen Landwirtschafts-Gesellschaft.

Note of occurrence of *Cronartium ribicola* in Silesia.

1901. Brick, C. Jahresbericht des Sonderausschusses für Pflanzenschutz, 1900, p. 190. In Arbeiten der Deutschen Landwirtschafts-Gesellschaft.

Note of occurrence of *Cronartium ribicola* in Lübeck.

1901. Marchal, Émile. Rapport sur les maladiés cryptogamiques in 1900. Bulletin de l'Agriculture, vol. 17, pp. 7–10.

Note of occurrence of *Cronartium ribicola* in Belgium in 1900.

1901. Reh, L. Jahresbericht des Sonderausschusses für Pflanzenschutz, 1900, p. 190. In Arbeiten der Deutschen Landwirtschafts-Gesellschaft.

Note of occurrence of *Cronartium ribicola* in Hamburg.

1901. Ritzema Bos, J. Landbouwkundig Tijdschrift, vol. 9, p. 77.

Peridermium strobi is so widespread in Holland that the culture of white pine has been given up. The original work has not been seen.

1901. Schøyen, W. M. Beretning om Skadeinsekter og Plantesygdomme i 1900, pp. 24–25.

An account of the currant felt rust upon Ribes: Schøyen advises against growing the two hosts together.

1901. Sorauer, P. Jahresbericht des Sonderausschusses für Pflanzenschutz, 1900, p. 1900. In Arbeiten der Deutschen Landwirtschafts-Gesellschaft.

Note of occurrence of *Cronartium ribicola* in Westphalia, Germany.

1901*a*. Tubeuf, C. von. Infektionsversuche mit Peridermium strobi dem Blasenroste der Weymouthskiefer. Arbeiten aus der Biologischen Abteilung für Land- und Forstwirthschaft am Kaiserlichen Gesundheitsamte, vol. 2, pp. 173–175.

Summary of infection experiments by various authors with *Peridermium strobi* spores upon Bibes.

1901 *b*. ——— Ueber Tuberculina maxima, einen Parasiten des Weymouthskiefern-Blasenrostes. Arbeiten aus der Biologischen Abteilung für Land- und Forstwirthschaft am Kaiserlichen Gesundheitsamte, vol. 2, pp. 169–173.

Account of *Tuberculina maxima* occurring as a parasite upon *Peridermium strobi*.

1901 *c*. ——— Einiger Beobachtungen über die Verbreitung parasitärer Pilze durch den Wind. Arbeiten aus der Biologischen Abteilung für Land- und Forstwirthschaft am Kaiserlichen Gesundheitsamte, vol. 2, pp. 175–177.

An account of the distribution of fungous spores by the wind, with particular mention of *Cronartium ribicola*.

1901. Weiss, J. E. Jahresbericht des Sonderausschusses für Pflanzenschutz, 1900, p. 190. In Arbeiten der Deutschen Landwirtschafts-Gesellschaft.

Note of occurrence of *Cronartium ribicola* in Bavaria, Germany.

1902. Brick, C. Jahresbericht des Sonderausschusses für Pflanzenschutz, 1901, p. 208. In Arbeiten der Deutschen Landwirtschafts-Gesellschaft.

Note of occurrence of *Cronartium ribicola* in Hamburg and Lübeck.

1902 *a*. Hennings, P. Ueber das epidemische Auftreten von Cronartium ribicola Dietr. im Dahlemer botanischen Garten. Notizblatt des Königlichen Botanischen Gartens und Museums zu Berlin, vol. 3, no. 28, pp. 172–175.

Gives observations on *Cronartium ribicola* around Berlin, with a list of Ribes found affected.

1902 *b*. ——— Beobachtungen über das verschiedene Auftreten von Cronartium ribicola Dietr. auf verschiedenen Ribes-Arten. Zeitschrift für Pflanzenkrankheiten, vol. 12, pp. 129–132.

Nearly the same as the above.

1902. Kirchner, O. Jahresbericht des Sonderausschusses für Pflanzenschutz, 1901, p. 208. In Arbeiten der Deutschen Landwirtschafts-Gesellschaft.

Note of occurrence of *Cronartium ribicola* in Wurttemberg.

1902. Klebahn, H. Jahresbericht des Sonderausschusses für Pflanzenschutz, 1901, p. 208. In Arbeiten der Deutschen Landwirtschafts-Gesellschaft.

Note of occurrence of *Cronartium ribicola* in Schleswig-Holstein and Hamburg.

1902. Magnus, P. Ueber Cronartium ribicola Dietr. Notizblatt des Königlichen Botanischen Gartens und Museums zu Berlin, vol. 3, no. 29, pp. 183–185.

Gives an account of Tranzschel's work in inoculating Ribes with spores from *Pinus cembra*.

1902. Marchal, Émile. In Belgien im Jahre 1901 beobachtete pilzparasitäre Krankheiten. Zeitschrift für Pflanzenkrankheiten, vol. 12, p. 49.

Note of occurrence of *Cronartium ribicola* in Belgium.

1902. Rea, Carleton. Transactions, British Mycological Society, 1900–1901, p. 164.

Note of occurrence of *Cronartium ribicola* at Exeter, England.

1902. Reh, L. Jahrbuch der Hamburgischen Wissenschaftlichen Anstalten, 3d ed., vol. 19, p. 130.

Note of occurrence of *Cronartium ribicola* in Oldenburg.

1902. Ritzema Bos, J. Verslag over onderzoekingen, gedaan in-en over inlichtingen gegeven van wege bovengenoemd laboratorium in het jaar 1901. Tijdschrift over Plantenziekten, vol. 8, p. 22. (In Dutch; the original not read.)

1902. Rostrup, E. Plantepatologi, pp. 308–313 and figs. 124–127. (In Danish.)

Made successful inoculations with *Peridermium strobi* from white pine onto *Ribes gracile*, *R. divaricatum*, and *R. multiflorum;* about 1877 there was a severe outbreak upon 20 to 30 year old white pine. In a footnote he says he has found Peridermium upon *Pinus excelsa*, implying that it was *P. strobi* but not definitely saying so. Recommends the separation of the two host genera and the removal of all diseased branches and stems.

1902. Sorauer, P. Jahresbericht des Sonderausschusses für Pflanzenschutz, 1901, p. 208. In Arbeiten der Deutschen Landwirtschafts-Gesellschaft.

Note of occurrence of *Cronartium ribicola* in Berlin.

1903. Berg, A. Bekaempelsen af Plantesygdomme og skadelige Insekter.

The original has not been seen.

1903. Bondarzev, A. S., and Bucholtz, F. Die Pilzparasiten des Sommers 1902 in der Umgebung von Riga. Zeitschrift für Pflanzenkrankheiten, vol. 13, p. 220.

Note of occurrence of *Cronartium ribicola* at Riga, Russia.

1903. Ewert, R. Das Auftreten von Cronartium ribicolum auf verschiedenen Ribes-Arten in den Anlagen des Kgl. Pomologischen Instituts zu Proskau. Zeitschrift für Pflanzenkranheiten, vol. 13, pp. 92–93.

The white-pine blister rust is very widespread in the protective plantings of the Pomeranian Institute, even old trees being affected. Gives lists of diseased and immune Ribes.

1903. Fox, William F. Forest nurseries and nursery methods in Europe. Reports 8 and 9, New York Forest, Fish, and Game Commission, pp. 201–235.

1903. Hennings, P. Beitrag zur Pilzflora des Gouvernements Moskau. Hedwigia, vol. 42, Beiblatt, p. (109).

Note of occurrence of *Cronartium ribicola* at Moscow, Russia.

1903. Kempton, H. B. The planting of white pine in New England. Bulletin 45, Bureau of Forestry, U. S. Dept. of Agriculture, p. 10.

1903. Marchal, Émile. Rapport sur les observations effectuées par le Service Phytopathologique de l'Institut Agricole de l'Etat en 1902. Bulletin de l'Agriculture, vol. 19, p. 169.

Note of occurrence of *Cronartium ribicola* in Belgium.

1903. Ritzema Bos, J. Verslag over onderzoekingen gedaan in-en over inlichtingen gegeven van wege bovengenoemn laboratorium in het jaar 1902. Tijdschrift over Plantenziekten, vol. 9, pp. 11–12. (In Dutch; original not read.)

1903. Schøyen, W. M. Beretning om Skadeinsekter og Plantesygdomme i 1902, p. 21.

Note of occurrence of *Cronartium ribicola* in Sweden in 1902.

1903. Staritz, R. Beiträge zur Pilzkunde des Herzogtums Anhalt. Verhandlungen des Botanischen Vereins der Provinz Brandenburg, vol. 45, p. 73.

Note of occurrence of *Cronartium ribicola* in Saxony.

1903. Thaler. Waldschädlinge des Jahres 1902. Allgemeine Forst- und Jagd-Zeitung, vol. 79, p. 404.

A number of head foresters reported that white-pine seedlings bought of private nurseries were diseased with the blister rust; part of the plants showed the disease the second spring after being planted out. Thaler cautions against buying diseased stock.

1904. Brick, C. Jahresbericht des Sonderausschusses für Pflanzenschutz, 1903, pp. 151–152. In Arbeiten der Deutschen Landwirtschafts-Gesellschaft.

Note of occurrence of *Cronartium ribicola* in Hamburg.

1904. Dietel, P. Betrachtungen die Verteilung der Uredineen auf ihren Nährpflanzen. Centralblatt für Bakteriologie, Parasitenkunde und Infektionskrankheiten, pt. 2, vol. 12, pp. 218–234.

Statement of heteroecism of *Cronartium ribicola*.

1904. Endler. Jahresbericht des Sonderausschusses für Pflanzenschutz, 1903, pp. 151–152. In Arbeiten der Deutschen Landwirtschafts-Gesellschaft.

Note of occurrence of *Cronartium ribicola* in Saxony.

1904. Ewert, R. Jahresbericht des Sonderausschusses für Pflanzenschutz, 1903, pp. 151. In Arbeiten der Deutschen Landwirtschafts-Gesellschaft.

Note of occurrence of *Cronartium ribicola* in upper Silesia.

1904. Fischer, Ed. Die Uredineen der Schweiz, pp. xxxii, xl, xlvi, lxxxi, 433–436.

Notes of occurrence of *Cronartium ribicola* in Switzerland on *Pinus cembra* and Ribes.

1904. Jaap, Otto. Erster Beitrag zur Pilzflora der Umgegend von Putlitz. Verhandlungen des Botanischen Vereins der Provinz Brandenburg, vol. 46, p. 129.

Note of occurrence of *Cronartium ribicola* in Brandenburg, Germany.

1904. Jaczewski, A. A. Yezhegodnik sviedienii o boliezniakh i povrezhdeniiakh kulturnykh i dikorastushchykh poleznykh rastenii, vol. 1, p. 111–112. (In Russian.) Reviewed by Bessey, E. A., in Journal of Mycology, 1905, vol. 11, p. 175.

An account of the life history of *Cronartium ribicola*, with notes of occurrence in Livland, Poland, Kursk, and St. Petersburg, Russia, and in Tomsk, Siberia.

1904 *a*. Klebahn, H. Die wirtwechselnden Rostpilze, pp. 15–17, 21–22, 25, 26, 40, 41, 45, 78–81, 94, 111, 134, 142, 164, 186, 191, 194, 196, 382–387.

The most complete account of *Cronartium ribicola* and the disease caused by it; gives list of first occurrences in different European countries, list of pines, and list of Ribes known to have been diseased.

1904 *b*. ——— Jahresbericht des Sonderausschusses für Pflanzenschutz, 1903; pp. 151–152. In Arbeiten der Deutschen Landwirtschafts-Gesellschaft.

Note of occurrence of *Cronartium ribicola* in Schleswig-Holstein, Germany.

1904. Kornauth, K. Pathologische Vorkommnisse in Österreich–Ungarn. Zeitschrift für Pflanzenkrankheiten, vol. 14, p. 353.

Note of occurrence of *Cronartium ribicola* in Bohemia.

1904. Noack, F. Phytopathologische Beobachtungen aus Belgien und Holland. Zeitschrift für Pflanzenkrankheiten, vol. 14, p. 349.

Note of destructive occurrence of *Cronartium ribicola* in Holland.

1904. Schellenberg, D. H. C. Der Blasenrost der Arve. Naturwissenschaftliche Zeitschrift für Land- und Forstwirtschaft, vol. 2, pp. 233–241 and fig. 2.

The best account of *Peridermium strobi* upon *Pinus cembra*.

1904. Schüle, W. Jahresbericht des Sonderausschusses für Pflanzenschutz, 1903, pp. 151–152. In Arbeiten der Deutschen Landwirtschafts-Gesellschaft.

Note of occurrence of *Cronartium ribicola* in Alsace, Germany.

1904. Weiss, J. E. Jahresbericht des Sonderausschusses für Pflanzenschutz, 1903, pp. 151–152. In Arbeiten der Deutschen Landwirtschafts-Gesellschaft.

Note of occurrence of *Cronartium ribicola* in Bavaria, Germany.

1905. Jaap, Otto. Beiträge zur Pilzflora von Mecklenburg. Annales Mycologici, vol. 3, p. 396.

Note of occurrence of *Cronartium ribicola* in Mecklenberg.

1905. Jaczewski, A. A. Listok dlia barby s bolieznіami i povrezhdeniami kulturnykh i dikorastushchykh poleznykh rastenii, vol. 4, no. 7, pp. 61–64. (In Russian.)

Describes the effects of *Cronartium ribicola* upon diseased Ribes; when the leaves are shed prematurely the fruit shrivels, and the bushes finally die if the disease recurs year after year. Experiments have shown that the teleutospores can not infect Ribes. Inoculations on Ribes at the end of May gave uredospores in the middle of July and teleutospores in August.

1905 *a*. Klebahn, H. Kulturversuche mit Rostpilzen, XII. Zeitschrift für Pflanzenkrankheiten, vol. 15, pp. 85–92 and pl. 3.

Account of successful inoculation of *Pinus strobus* with teleutospores of *Cronartium ribicola*.

1905 *b*. ——— Jahresbericht des Sonderausschusses für Pflanzenschutz, 1904, p. 171. In Arbeiten der Deutschen Landwirtschafts-Gesellschaft.

Note of occurrence of *Cronartium ribicola* in Germany.

1905. Lüstner, G. Jahresbericht des Sonderausschusses für Pflanzenschutz, 1904, p. 171. In Arbeiten der Deutschen Landwirtschafts-Gesellschaft.

Note of occurrence of *Cronartium ribicola* in Hesse.

1905. Marchal, Émile. Rapport sur les observations effectuées par le Service Phytopathologique de l'Institut Agricole de l'Etat en 1904. Bulletin de l'Agriculture, vol. 21, p. 75.

Note of occurrence of *Cronartium ribicola* in Belgium on *Pinus strobus*.

1905. Oppenau. Jahresbericht des Sonderausschusses für Pflanzenschutz, 1904, p. 171. In Arbeiten der Deutschen Landwirtschafts-Gesellschaft.

Note of occurrence of *Cronartium ribicola* in Baden.

1905. Schüle, W. Jahresbericht des Sonderausschusses für Pflanzenschutz, 1904, p. 171. In Arbeiten der Deutschen Landwirtschafts-Gesellschaft.

Note of occurrence of *Cronartium ribicola* in Alsace.

1905. Spieckermann, A. Jahresbericht des Sonderausschusses für Pflanzenschutz, 1904, p. 171. In Arbeiten der Deutschen Landwirtschafts-Gesellschaft.

Note of occurrence of *Cronartium ribicola* in Westphalia.

1905 *a*. Tubeuf, C. von. Über die Biologie, praktische Bedeutung und Bekämpfung des Weimutskiefern-Blasenrostes. Kaiserliche Biologische Anstalt für Land- und Forstwirtschaft, Flugblatt, no. 5, pp. 1–4, and col. pl. 1.

A very good popular account of the white-pine blister rust and the disease caused by it, with recommendations for combating it. A translation by A. J. T. van Laer was published by the New York State Department of Agriculture in 1909.

1905 *b*. ——— In Lafar's Handbuch der technischen Mykologie, vol. 3, pp. 296–297.

Incidental mention of *Cronartium ribicola*.

1905 *c*. ——— Der Blasenrost der Weymouthskiefer. (A colored chart 16 by 19 inches, with sixteen figures, showing various stages of the fungus and the disease. Issued by the Biologische Abteilung des Kaiserlichen Gesundheitsamtes. This chart has been distributed to inspectors and others by the Bureau of Plant Industry. See page 50.)

1905. Voglino, P. Patologia vegetale, p. 209.

Statement of heterœcism of *Cronartium ribicola*.

1906. Appel, Otto. Der Weymouthskiefern-Blasenrost. Mittheilungen aus der Kaiserlichen Biologischen Anstalt für Land- und Forstwirtschaft in Dahlem bei Steglitz, vol. 2, p. 20.

Appel says that successful inoculations have been made on about forty species of Ribes, but does not name them.

1906. Bondarzev, A. S. Rastitelnyie parazity kulturnykh i dikorastushchykh ras tenii. Sobranie v Kurskoi gubernii lyetom 1901, 1903–1905 godov. Acta Horti Petropolitani, vol. 26, pp. 19, 40.

Found year after year in the same gardens on Ribes in Kursk, Russia; no *Pinus cembra* or *P. strobus* known in the vicinity.

1906. Jaczewski, A. A. Yezhegodnik sviedienii o boliezniakh i povrezhdeniiakh kulturnykh i dikorastushchykh poleznykh rastenii, vol. 2, pp. 85–86, 98. (In Russian.)

Inoculations upon *Ribes rubrum*, *R. nigrum*, and *R. grossularia* with æcidiospores from *Pinus strobus* were successful only on the first. Found on *Ribes nigrum* in the Governments of Kursk, Tula, and Orlov; on *Pinus strobus* in the Governments of Livland, Smolensk, and Moscow; on *Pinus cembra* in the Government of St. Petersburg, Russia.

1906. Mayr, Heinrich. Fremdländische Wald- und Parkbäume für Europa, pp. 374–375, 587.

States that ten years ago the disease was sent in some trees to the Forestry Experiment Garden at Grafrath; they were removed and burned two years later, when the disease appeared.

1906. Neger, F. W. Über Peridermium strobi auf Pinus monticola Dougl. Annales Mycologici, vol. 4, p. 280.

Neger found the white-pine rust on *Pinus monticola* at Tharandt, Germany.

1906. P———y. Ein neuer Feind unserer Weymouthskiefernkulturen. Schweizerische Zeitschrift für das Forstwesen, vol. 57, pp. 46–48.

The writer says that the white pine grows well in the high Juras, but that lately a new enemy, the blister rust, has appeared; it mostly kills trees six or seven years of age, but older ones are merely stunted in growth; he recommends raising one's own seedlings and the removal of Ribes from the vicinity.

1906 *a*. Rostrup, E. Cronartium paa Ribes aureum. Gartner-Tidende, August 30.

The original has not been seen.

1906 *b*. ——— Cronartium paa Stikkelsbärblade. Gartner-Tidende, November 22.

The original has not been seen.

1906. Stewart, F. C. An outbreak of the European currant rust (Cronartium ribicola Dietr.). Tech. Bulletin 2, New York Agricultural Experiment Station (Geneva), pp. 61–74.

A very good account of the Cronartium stage of *C. ribicola* as discovered by Stewart in the experiment station currant plantation; the origin of the outbreak is unknown. The entire plantation was uprooted and burned and the fungus apparently completely eradicated.

1906. Takahashi, Y. Notes on some parasitic fungi of Japan. Transactions of the Sapporo Natural History Society, vol. 1, pp. 177–179, 181.

States that *Cronartium ribicola* has been found on *Ribes rubrum* at Sapporo, Japan, and on Sakhalin Island, but the æcidial stage has not been found.

1907 *a*. (Anonymous.) Krankheiten und Beschädigungen der Kulturpflanzen im Jahre 1905. Berichte über Landwirtschaft, vol. 5, pp. 142, 154.

A condensed statement of the occurrence of *Cronartium ribicola* in various parts of Germany in 1905.

1907 *b*. (Anonymous.) Journal of the Board of Agriculture (London), vol. 14, pp. 480–481.

Found *Cronartium ribicola* on *Ribes nigrum* at Westbury, England.

1907. Arthur, J. C. North American flora, vol. 7, pp. 122–123.

Scientific description of *Cronartium ribicola*.

1907. Bruck, W. F. Pflanzenkrankheiten, pp. 26, 91, 130.

Statement of hosts and heterœcism of *Cronartium ribicola*.

1907. Fischer, Ed. Ueber die durch parasitische Pilze (besonders Uredineen) hervorgerufenen Missbildungen. Verhandlungen der Schweizerischen Naturforschenden Gesellschaft, 89 Jahresversammlung, in St. Gallen, 1907, p. 176.

Cronartium ribicola causes the leaves of *Pinus strobus* to grow shorter and broader than normally; Klebahn believes it an undoubted return to the juvenile form.

1907. Jaap, Otto. Mykologisches aus dem Rhöngebirge. Allgemeine Botanische Zeitschrift, vol. 13, p. 187.

Note of occurrence of *Cronartium ribicola* in Germany.

1907. Juel, O. Öfversikt af våra värdväxlande rostsvampar. Svensk Botanisk Tidskrift, vol. 1, p. 247.

Cronartium ribicola is mentioned as occurring in Sweden.

1907. Kornauth, K. K. K. Landwirtschaftlich-Bakteriologische und Pflanzenschutzstation. Zeitschrift für das Landwirtschaftliche Versuchswesen in Oesterreich, vol. 10, pp. 208, 209.

Cronartium ribicola is mentioned as occurring on white pine in Bohemia and the Tyrol.

1907. Liro, J. I. Kulturversuche mit finnischen Rostpilzen. Acta Societatis pro Fauna et Flora Fennica, vol. 29, no. 7, p. 22.

Liro proved that *Peridermium pini* has no connection with *Cronartium ribicola* by inoculations on leaves of *Ribes grossularia*, *R. nigrum*, and *R. rubrum* with spores of the former without infection occurring.

1907. Marchal, Émile. Rapport sur les observations effectuées par le Service Phytopathologique de l'Institut Agricole de l'Etat en 1906. Bulletin de l'Agriculture, vol. 23, p. 40.

Note of occurrence of *Cronartium ribicola* in Belgium in 1906.

1907. Neger, F. W. Die Nadelhölzer, pp. 110, 111.

Neger says the white-pine blister rust is the most destructive disease of *Pinus strobus* in Europe.

1907. Neger, F. W., and Büttner, G. Ueber Erfahrungen mit der Kultur fremdländischer Koniferen im akademischen Forstgarten zu Tharandt. Naturwissenschaftliche Zeitschrift für Land- und Forstwirtschaft, vol. 5, p. 208.

Cronartium ribicola is mentioned as occurring on *Pinus monticola.*

1907. Pechon, L. Principales maladies des arbres et des peuplements forestiers. Bulletin de la Société Centrale Forestière de Belgique, 14, pp. 329–330.

A good description of *Cronartium ribicola* upon older trees of white pine; occurs seriously on trees in the forests in Ardennes, France; gives methods of combating.

1907. Potebnia, A. Verzeichnis der in Mittel-Russland (Gouv. Kursk und Charkow) gesammelten Pilze. Annales Mycologici, vol. 5, p. 12.

Note of occurrence of *Cronartium ribicola* in Russia.

1907. Ritzema Bos, J., Staes, G., and Hall, C. J. J. van. Phytopathologische Beobachtungen aus Holland. Zeitschrift für Pflanzenkrankheiten, vol. 16, p. 145.

Note of occurrence of *Cronartium ribicola* on *Pinus strobus* in Holland.

1907. Stewart, F. C. An outbreak of the European currant rust, Cronartium ribicola Dietr. Science, n. s., vol. 25, p. 262.

A brief note on the discovery of this fungus In America.

1908. (Anonymous.) Journal of the Board of Agriculture (London), vol. 15, p. 689.

Note of occurrence of *Cronartium ribicola* at Hailsham and Ipswich, England.

1908. Bubák, Franz. Die Pilze Böhmens, vol. 1, pp. 176–177. (Archiv für die Naturwirtschaftliche Landesdurchforschung von Böhmen, vol. 13, no. 5.)

Notes of occurrence of *Cronartium ribicola* in Bohemia.

1908. Clinton, G. P. Heterœcious rusts of Connecticut having a peridermium for their æcial stage. Report of Botanist, Connecticut Agricultural Experiment Station, 1907, p. 394.

Cronartium ribicola is liable to be introduced on white pine from Europe.

1908. Ducomet, V. Botanique agricole. Pathologie végétale, p. 173.

Bare mention of *Cronartium ribicola.*

1908. Hariot, Paul. Les Urédinées, p. 281.

Brief mention of *Cronartium ribicola.*

1908. Jaczewski, A. A. Yezhegodnik sviedienii o boliezniakh i povrezhdeniiakh kulturnykh i dikorastushchykh poleznykh rastenii, vol. 3, pp. 142–143, 188. (In Russian.)

Cronartium ribicola is often found in the Government of St. Petersburg on *Ribes nigrum;* much *Pinus cembra* is present but no *P. strobus.* In the city of Kursk black currants near diseased white pine were worse affected than those farther away. Reported from Government of Voronej on *Ribes rubrum* as well as *R. nigrum;* from Livland, and from city of Tomsk, Siberia.

1908. Klebahn, H. Kulturversuche mit Rostpilzen, XIII. Zeitschrift für Pflanzenkrankheiten, vol. 17, pp. 148–149.

Made inoculations with *Peridermium pini* upon Ribes without result.

1908. Köck, Gustav. Krankheiten und Schädlinge des Beerenobstes und ihre Bekämpfung. Mitteilungen der K. K. Landw. Bakter. und Pflanzenschutzstation in Wien, p. 9. (Separate from Blätter für Obst-, Wein- und Gartenbau, no. 136.)

Köck says that the currant felt rust occurs frequently and cautions against growing the two hosts together.

1908 *b*. Köck, Gustav. Die häufigsten pilzlichen Krankheiten unserer wichtigsten Nadelhölzer und ihre Bekämpfung. Mitteilungen der K. K. Landw. Bakter. und Pflanzenschutzstation in Wein, pp. 15–16. (Separate from Landes-Amtsblatt des Herzogtumes Österreich unter der Ems, June 15 and July 1.)

General statement of hosts of *Cronartium ribicola;* says it is very destructive and recommends removing and burning the affected parts and plants and the separation of the two hosts.

1908. Laubert, R. Ueber den Wirtswechsel des Blasenrostes der Kiefern (Peridermium pini). Deutsche Landwirtschaftliche Presse, vol. 35, pp. 596–597.

Brief statement of heteroecism of *Cronartium ribicola.*

1908. Neger, F. W. Ein Infektionsversuch mit Peridermium strobi von Pinus monticola. Naturwissenschaftliche Zeitschrift für Land- und Forstwirtschaft, vol. 6, p. 605.

Planted several species of Ribes near trees of *Pinus monticola* which were affected with the white-pine blister rust; only *Ribes sanguineum* became diseased.

1908. Palm, Björn. Till kännedomen om Stockholmstraktens Svampflora. Svensk Botanisk Tidskrift, vol. 2, p. 39.

Note of occurrence of *Cronartium ribicola* in Sweden.

1908. Peck, Charles H. Report, New York State Botanist, 1907, p. 20.

Note on Stewart's discovery of *Cronartium ribicola* in the State of New York.

1908. Sorauer, P. Handbuch der Pflanzenkrankheiten, vol. 2, p. 349.

A general account of the life history of *Cronartium ribicola.*

1908. Turconi, M. Intorno alla micologia Lombarda. Memoria Prima. Atti dell' Istituto Botanico della R. Università di Pavia, vol. 12, p. 118.

Note of occurrence of *Cronartium ribicola* in Italy.

1909. (Anonymous.) Canadian Forestry Journal, vol. 5, pp. 165–166.

Brief mention of discovery of *Peridermium strobi* in New York.

1909. (Anonymous.) Forestry Quarterly, vol. 7, p. 487.

Mentions Von Reitzenstein's statement that the nurseries of Halstenbek are now free from the white-pine blister rust.

1909. Atwood, G. G. Emergency bulletin on the blister rust of pines and the European currant rust. Hort. Bulletin 2, Dept. of Agriculture, State of New York, pp. 1–20.

A good popular account of the discovery of *Cronartium ribicola* on white pines in America in 1909; the life history of the fungus, description of the disease, measures taken to eradicate it, and a partial reprint of Stewart's bulletin (1906).

1909. Beissner, L. Handbuch der Nadelholzkunde, pp. 349, 353, 693 (2d ed.).

States that *Pinus strobus* and *P. monticola* suffer from the blister rust, the treatment of which must be immediately considered upon its appearance.

1909. Curtis, Ellicott D. Rejoinder to D. Hill on cost of evergreen seedlings. Forestry Quarterly, vol. 7, p. 254.

Says the white-pine blister rust is liable to reduce the amount of planting that will be done in the next few years.

1909. Delacroix, G., and Maublanc, A. Maladies des plantes cultivées, p. 185.

A brief statement of heteroecism of *Cronartium ribicola.*

1909. Duggar, B. M. Fungous diseases of plants, pp. 433–435.

A short account of the white-pine blister rust and the disease caused by it.

1909. Fisher, W. R. Experimental plantations at Cooper's Hill. Quarterly Journal of Forestry, vol. 3, p. 229.

No white-pine blister rust is found at Cooper's Hill, but it is exterminating white pine at Woburn and is very prevalent in the Windsor Forest.

1909. Griffon, E., and Maublanc, A. Notes de pathologie végétale (mildiou, black-rot, rouilles). Bulletin de la Société Mycologique de France, vol. 25, p. 144.

Says *Peridermium strobi* occurs in a nursery at Paris; also mentions its occurrence destructively in the Forest of Fontenoy.

1909. Kirchner, O., and Boltshauser, H. Atlas der Krankheiten und Beschädigungen unserer landwirtschaftlichen Kulturpflanzen, ser. 6, pl. 15.

A colored plate showing *Cronartium ribicola* on *Pinus strobus*.

1909. Klugkist, C. E. Zur Kenntnis der Schmarotzerpilze Nordwestdeutschlands. Abhandlungen herausgegeben vom Naturwissenschaftlichen Verein zu Bremen, vol. 19, p. 396.

Note of occurrence of *Cronartium ribicola* in Germany.

1909. ——— Vierter Beitrag: Flora von Celle. Abhandlungen herausgegeben vom Naturwissenschaftlichen Verein zu Bremen, vol. 19, pp. 407, 409.

Notes of occurrence of *Cronartium ribicola* in both stages in Hanover, Germany.

1909. Köhler. Dendrologische Mitteilungen. Mitteilungen der Deutschen Dendrologischen Gesellschaft, 1892–1898, p. 277.

The white-pine blister rust is killing the white pines of the Altenburg park; sprinkled with a strong stream of cold water the forming blisters disappeared.

1909. Pettis, C. R. The white-pine blister rust. Forestry Quarterly, vol. 7, pp. 231–235.

A very good short statement concerning the white-pine blister rust and the procedure adopted in New York in eradicating it.

1909. Reitzenstein, von. Die Baumschulen von H. H. Pein in Halstenbek (Holstein). Forstwissenschaftliches Centralblatt, vol. 31, p. 36.

Von Reitzenstein says that a few years ago the white-pine blister rust caused discrimination against white-pine seedlings raised in Halstenbek, but that it is now entirely eradicated.

1909. Rikli, M. Die Arve in der Schweiz. Neue Denkschriften der Schweizerischen Naturforschenden Gesellschaft, vol. 44, pp. 429–430.

Contains a statement of what other writers have said concerning the occurrence of *Cronartium ribicola* in Switzerland on *Pinus cembra*.

1909. Schelle, E. Die winterharten Nadelhölzer Mitteleuropas, pp. 25–26.

Gives methods of combating the white-pine blister rust.

1909. Schenck, C. A. Forest protection, p. 119.

A good brief statement concerning the white-pine blister rust.

1909. Somerville, W. Peridermium strobi, the blister of Weymouth pine. Quarterly Journal of Forestry, vol. 3, pp. 232–236.

The white pine is being exterminated in Britain and *Pinus monticola* is seriously attacked; Canada and the United States should prohibit the importation of foreign stock of five-leaved pines and Ribes; the damage will be appalling if it becomes established in America and causes as much damage as it is now doing in England.

1909 *a*. Spaulding, Perley. European currant rust on the white pine in America. Circular 38, Bureau of Plant Industry, U. S. Dept. of Agriculture, pp. 1–4.

A short account of the importation of the white-pine blister rust into America in 1909, its record in Europe, and methods of eradication.

1909 *b*. ——— Peridermium strobi Klebahn in America. Science, n. s., vol. 30, pp. 200–201.

Similar to the above.

1909. Zon, Raphael. Forestry Quarterly, vol. 7, p. 236.

Notes on the history of *Cronartium ribicola* in Europe.

1910. (Anonymous.) Biennial report of the New Hampshire Forestry Commission for the years 1909–1910, pp. 82–83.

A statement of the occurrence of the blister rust in this country and in New Hampshire.

1910. (Anonymous.) Science, n. s., vol. 31, p. 699.

Resolutions by the American Phytopathological Society; views with alarm the recent introduction of *Chrysophlyctis endobiotica* and *Peridermium strobi* into America, deplores absence of regulation of importations, regards situation as serious, and pledges support to legislation for control of importation.

1910. (Anonymous.) Canadian customs regulations, May 11, 1910.

Places *Peridermium strobi* among the proscribed fungi under the Destructive Insect and Pest Act.

1910. (Anonymous.) Peridermium strobi. Quarterly Journal of Forestry, vol. 4, p. 140.

Notes the discovery of *Peridermium strobi* in the United States, and states that it "must be regarded as most serious, and it is to be hoped that the steps being taken to exterminate it will prove successful.

1910. Jaap, Otto. Ein kleiner Beitrag zur Pilzflora der Eifel. Annales Mycologici, vol. 8, p. 146.

1910. Peck, Charles H. Bulletin 139, New York State Museum, p. 27.

Cronartium ribicola is mentioned as being destructive to white pine.

1910. Pettis, C. R. The European blister rust. Report, New York Forest, Fish, and Game Commission, vol. 15, pp. 148–164 and pl. 3.

An account of the discovery of the white-pine blister rust in New York and adjacent States, action taken by the meeting of foresters concerned, rules of procedure for the New York inspectors, and a brief account of the life history of the fungus.

1910. Schander, R. Bericht über das Auftreten von Krankheiten und tierischen Schädlingen an Kulturpflanzen in den Provinzen Posen und Westpreussen im Jahre 1908. Mitteilungen des Kaiser Wilhelms Institutes für Landwirtschaft in Bromberg, vol. 2, p. 134.

Schander found the white-pine blister rust in 1908.

1910. Selby, A. D. A brief handbook of the diseases of cultivated plants in Ohio. Bulletin 214, Ohio Agricultural Experiment Station, pp. 396, 429.

Brief mention of this disease in the United States.

1910 *a*. Spaulding, Perley. Peridermium strobi, an importation from Europe. Science, n. s., vol. 31, pp. 78–79.

A brief summary of a paper presented before the Botanical Society of Washington.

1910 *b*. ——— European currant rust on white pine in America. Science, n. s., vol. 31, pp. 756–757.

A brief summary of a paper presented at the 1909 meeting of the American Association for the Advancement of Science.

1910. Stevens, F. L., and Hall, J. G. Diseases of economic plants, p. 155.

PLATES.

DESCRIPTION OF PLATES.

PLATE I. (*Frontispiece.*) *Cronartium ribicola* on *Pinus strobus* and Ribes. *A.*—A 4-year-old white-pine tree diseased with blister rust. Note the slight swelling of the stem in the area bearing the yellow spore pustules. *B.*—Leaf of *Ribes aureum* bearing many pustules of uredospores. *C.*—Enlarged detail of uredo pustules. *D.*—Leaf of *Ribes americanum* with a number of the hairlike growths of the teleutospore stage. These spores are capable of infecting pine, while the first two forms can not, but can infect the leaves of Ribes.

PLATE II. Fig. 1.—A stunted 4-year-old white-pine tree, showing cracked bark caused by bearing fruiting bodies the previous season. The stem is thickened somewhat from near the soil to the branches. Fig. 2.—A stunted 4-year-old white-pine tree bearing fruiting bodies on its stem. Note the short growth in top, not more than half the normal growth at this stage. The stem is thickened from the first branch to the top.

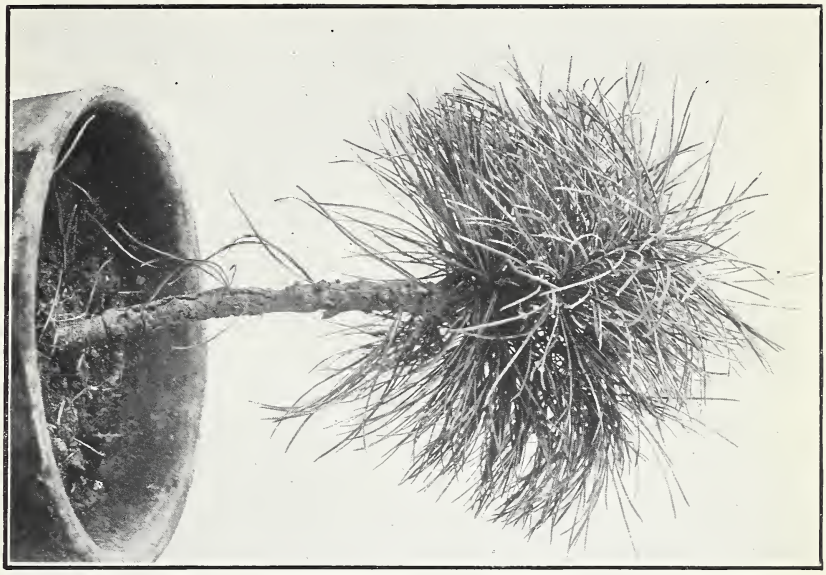


FIG. 1.—A STUNTED WHITE PINE SHOWING CRACKED BARK.

FIG. 2.—A STUNTED WHITE PINE BEARING FRUITING BODIES.

INDEX.

206