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WHITE-PINE BLISTER RUST IN WESTERN EUROPE.

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CONTENTS.

INTRODUCTION.

Following the outbreak of the white-pine blister rust in the northeastern United States and in Ontario, Canada, foresters and pathologists sought a method of combat, and to this end European literature was scanned for assistance (*40*)[1]. The European scientists who studied the causal fungus (*Cronartium ribicola* Fischer) had confined their research almost exclusively to its biology. Their investigations as summarized in literature contain many suggestions for combating the disease, and they advance the principle of control by host separation but yield nothing definite on the practical application of control measures suited to American conditions. During the period from 1917 to 1921 the United States Department of Agriculture, in cooperation with the New England States, New York, Wisconsin, and Minnesota, conducted extensive experiments to develop methods of practical control of the disease under forest conditions.

These experiments have fully demonstrated that under average forest conditions in the northeastern United States, white pine can

[1] The serial numbers (italic) in parentheses refer to "Literature cited" at the end of this bulletin.

be effectively protected (*10*). Control is accomplished by uprooting all wild and cultivated currant and gooseberry plants (Ribes) within a distance of 600 to 900 feet of the trees to be protected. The destruction of wild currant and gooseberry bushes can be accomplished at a cost sufficiently low to make it practicable and profitable to safeguard the valuable white-pine crop of the Northeastern States. In the five years from 1918 to 1922 the cost of removing 19,224,118 wild currant and gooseberry bushes from 1,504,945 acres of forest and pasture land averaged 31.8 cents per acre. Any white-pine stand protected in this manner is safe from further rust infection for at least 5 to 10 years, and in many cases permanently, depending on whether or not local conditions are favorable or unfavorable to the growth of wild currant and gooseberry bushes. Several years of careful study are required to develop and perfect the cheapest and simplest methods of control, since many phases of this work are still in the experimental stage. Meanwhile, the control measures that have been developed should be generally applied at once to prevent further losses from this disease.

The writer, a forester, observed the blister-rust situation in several European countries in 1919 and 1920 and takes this opportunity to acquaint others with his observations, which should be of especial interest to timberland owners on account of the rapid spread of the disease in the Northeastern States and its occurrence in British Columbia and Washington. Unless otherwise specified, the statements are based on the writer's observations. It would have been quite impossible to conduct the work without the assistance and advice of scientists, departments of agriculture, and forest officials in the countries visited. The writer wishes to express his sincere appreciation to those who freely gave their time and efforts, which contributed so largely to the progress of this work.

SCOPE OF THE INVESTIGATIONS.

The primary purpose of this work was to gather information regarding European methods of dealing with the white-pine blister rust which would assist in the control campaign in America. To accomplish this purpose, plantations of infected white pine were studied, foresters and pathologists interviewed, and data compiled as to the actual and financial loss caused by the disease. This work was supplemented by visiting the nurseries to observe their sanitary conditions, in order that a first-hand opinion might be formed as to the justification of the rigid quarantine regulations adopted by the United States against imported nursery stock. In addition, all available historical and biological data concerning the fungus were collected in Norway, Sweden, Denmark, Great Britain, France, and Belgium. Typical specimens of ornamental white pine were seen very frequently in European parks and arboretums (Pl. I.). Even under the most favorable conditions they become prey for the blister rust.

As the writer was in Sweden during the fall of 1919 and winter of 1919–20, work was begun in that country and extended to cover Norway and Denmark. By the middle of July the field was shifted to the British Isles, then to France and Belgium, which were completed on November 1, 1920. Miscellaneous notes were also gathered

by correspondence from other European countries, including Germany, Switzerland, Holland, and Russia, although these countries were not actually visited.

HISTORICAL REVIEW.

Both the Peridermium and Cronartium forms of *Cronartium ribicola* have been known in Europe for 65 years. Dietrich first used the name about 1856 in a collection of dried plants entitled "Plantarum Florae Balticae Cryptogamarum" (*11*, p. 287), and European writers generally attribute the name to him. Five years later, in 1861, W. Saellen discovered the fungus on white pine near Helsingfors, Finland. The form on Ribes, as far as is known, was not found in that country until 1897 (*28*, p. 447–449). Rostrup, in 1865, found the disease in Denmark on black currants, while Kornicke first found it in East Prussia in 1865 (*27*, p. 281). It was unknown in the rest of Germany until Fischer de Waldheim found it on *Ribes aureum* at Stralsund in 1871.[2] The following year Magnus found it on the same species at Kiel (*29*).

The disease was reported on one or both hosts from western Siberia in 1879,[3] Sweden in 1880 (*14*), Norway in 1885 (*7*, p. 70), Holland in 1885 (*32*, p. 239), France in 1889,[4] and during the following decades from the British Isles in 1892 (*33*), Belgium in 1894 (*31*), and Switzerland in 1895 (*15*). The date 1887 is perhaps the most significant in blister-rust history, for in that year Klebahn separated the old composite species *Peridermium pini* Willd. into three species, namely, *Peridermium pini ribicola* Kleb., *Peridermium cornui* Rostrup and Klebahn, and *Peridermium strobi* Kleb. (*23*).

In 1888 Klebahn determined by inoculation experiments the relationship between the Peridermium form on *Pinus strobus* and the Cronartium form on Ribes. The same year, in company with O. Nordstedt at Grimstorp, Westgotland, Sweden, this belief was verified when they found white pine and black currants growing close together and both badly diseased (*22*).

Following the determination of the host plants the fungus has been repeatedly found and reported from several European countries, attracting the attention of both mycologists and foresters. Its distribution covers nearly the whole of western Europe and the British Isles and, according to statements by members of the Norwegian forest service, extends to 63½° north latitude on the Norwegian coast. The date of the introduction of the blister rust into America is not known, but circumstantial evidence indicates that it was first introduced from Europe about 1898.

SUSCEPTIBILITY OF BLISTER-RUST HOSTS.

FIVE-NEEDLE PINES.

The current European opinion is that the fungus originated on *Pinus cembra* in Siberia, migrated to Europe, and became far more virulent on the exotic five-leaved pines than on its supposed original host. Contrary to the writer's expectations, he found no *Pinus*

[2] Rabenhorst, L. Fungi europaei exsicatti, No. 1595.
[3] Thuemen, Felix von. Mycotheca universalis, No. 2049.
[4] Specimen. Natural History Museum, Paris.

cembra infected in the countries visited, although a single instance of its occurrence on this species is reported from Switzerland (*37*). Besides occurring on *Pinus cembra* and *P. strobus*, it has been found (and seen by the writer, except as otherwise noted) in Europe on other species as follows: *P. ayacahuite* Ehrenb. (British Isles and Belgium), *P. excelsa* (Denmark, *36*, p. 312), *P. flexilis* (Belgium, France, Germany (*42*), Norway, Sweden), *P. koraiensis* (Sweden), *P. lambertiana* (Belgium, British Isles, France, Germany (*42*),[5] *P. monticola* (Belgium, British Isles, Germany (*42*)), *P. pentaphylla* (British Isles),[6] and *P. peuce* (Belgium,[7] Germany (*42*)).

Inoculation experiments successfully conducted by many European investigators show that all five-leaved pines and Ribes tested are susceptible to the fungus, though varying greatly in their degree of susceptibility. The experiments also prove the independence of the two forms *Peridermium pini* and *P. strobi*. It is worthy of mention at this point that the earliest known Cronartium on Ribes, though not *C. ribicola*, was collected by Jacquemont (*43*), the French explorer, in India in 1830 and determined by Leveille as *Cronartium asclepiadeum*.[8] This is particularly significant, since in 1914 a bark-inhabiting Peridermium was found on the Himalayan white pine (*Pinus excelsa*) and sent to the Mycological Bureau at Pusa, India. Dr. E. J. Butler, of the Bureau of Mycology at Kew, England, kindly forwarded a specimen of the Peridermium to the writer, who sent it to Dr. R. H. Colley, of the Office of Forest Pathology, for determination. He found it to be distinctly different from *Cronartium ribicola*.

CURRANTS AND GOOSEBERRIES.

Herbariums in the botanical museums were carefully scanned for Ribes species serving as hosts for *Cronartium ribicola* and for the localities and dates of occurrence. A total of 29 species was recorded, covering all the western European countries. Of the common Ribes, the most readily infected is *nigrum* (*41*), while *grossularia* and *rubrum* are less susceptible. The writer found the first-mentioned species, but not the last-mentioned, infected in Europe. In the Vilmorin Arboretum at Nogent sur Vernisson, Loiret, France, 35 species were examined, and only two were found infected, namely, *Ribes caucasicum* and *Ribes propinquum*, both of which were badly diseased. European foresters regard *Ribes nigrum* as the most dangerous species and consider other European Ribes as of little consequence as agents for harboring the white-pine blister rust.

CURRANTS AND GOOSEBERRIES KNOWN TO BE SUSCEPTIBLE.

The list of varieties shown in Table 1 includes all infected species of Ribes seen by the writer in herbariums and elsewhere in Europe, as well as those observed by a correspondent, Prof. O. Juel, in 1920, in the Botanical Gardens at Upsala, Sweden; but undoubtedly other host species exist in other European collections.

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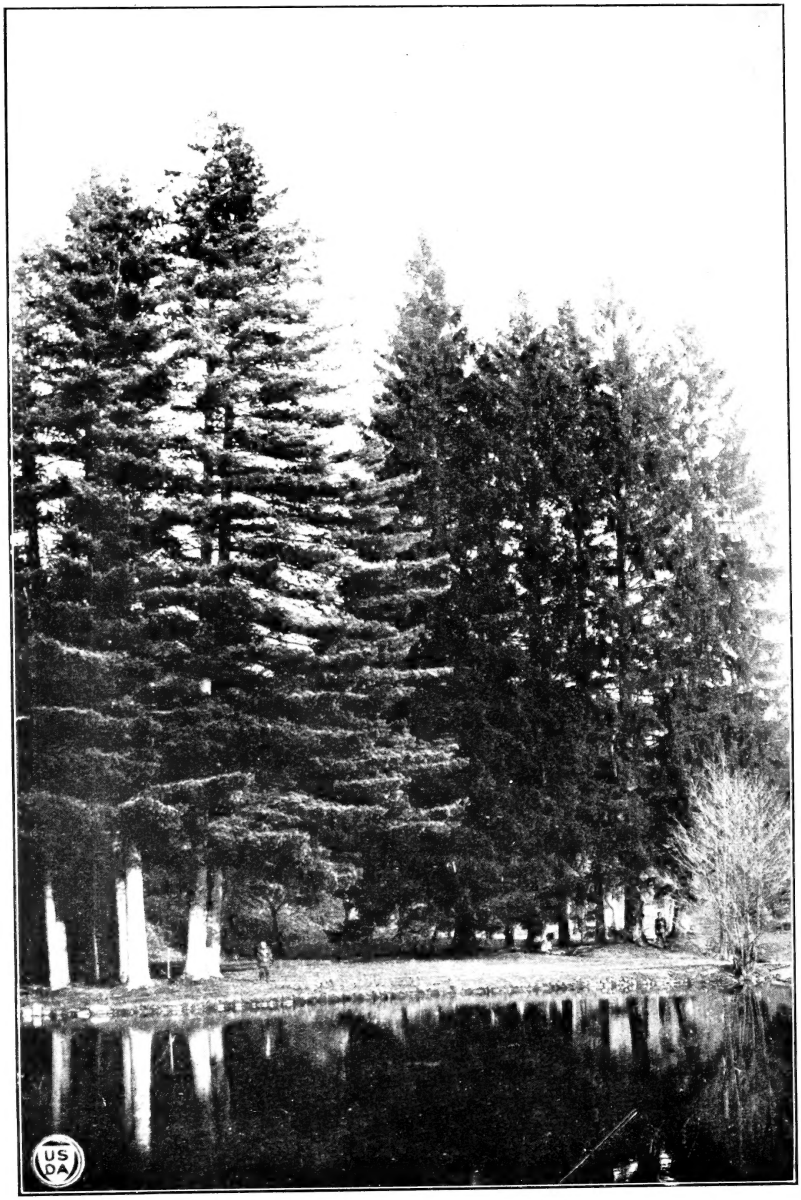
[5] Correspondence with Professor Von Tubeuf.
[6] Reported by the Forestry Commission for Scotland.
[7] Reported as having occurred at Groenendael, Belgium.
[8] Specimen in Cryptogamic Herbarium, Botanical Museum, Paris.

A CENTURY-OLD WHITE PINE IN BELGIUM.

This magnificent specimen in the Domaine of St. Ode, Luxembourg, is one of our finest American trees on foreign soil. Photographed by Prof. Charles Bommer, Brussels, Belgium.



A GROUP OF 70-YEAR-OLD WHITE PINES IN BELGIUM.

The largest tree in this group, at the farm St. Michel, near St. Hubert in the western Ardennes, in 1909 measured 110 feet in height, with a diameter of 33 inches at breast height. This tree would cut 1,400 board feet, valued in Europe at approximately $40 per thousand on the stump. Photographed by Prof. Charles Bommer, Brussels, Belgium.

TABLE 1.—*List of species of Ribes infected with blister rust as seen by the writer in certain herbariums and elsewhere in Europe and by Prof. O. Juel in the Botanical Gardens at Upsala, Sweden.*

[Names recorded from the specimen labels are shown in **boldface** type. The synonymy has been furnished by Dr. Frederick V. Coville, and the synonyms are here printed in SMALL CAPITALS. Doctor Coville believes that the gooseberries are more satisfactorily regarded as belonging to Grossularia, a genus distinct from Ribes, which comprises the currants. The species are so treated in the revision of the family Grossulariaceæ in the North American Flora (9). American species or varieties are designated by an asterisk (*). *Explanation of symbols.*—Bru=Botanical Museum, Brussels, Belgium; Chr=Botanical Museum, Christiania, Norway; Cop=Botanical Museum, Copenhagen, Denmark; Lon=British Museum, London, England; Sto=Royal Museum at Stockholm, Sweden (contains the herbariums of Rehms and Sydow, as well as those of Swedish collectors; Upsala=Botanical Gardens, Upsala, Sweden; Vil=Vilmorin Arboretum, Nogent sur Vernisson, France.]

Name of species.	Where seen.	Remarks.
Seen by the writer:		
albidum* L.	Lon.	This presumably is *Ribes albidum* Paxton, which is an albino form of *R. glutinosum* Benth.
alpinum L.	Chr, Lon, Sto.	
AMERICANUM* Mill.		See **floridum.**
apiifolium	Lon, Sto.	According to Janczewski (*22*) this is a horticultural variety of *R. nigrum* L.
atropurpureum Mey	do.	According to Janczewski this is a variety of *R. petraeum* Wulf.
aureum* Pursh	Chr, Cop, Lon, Sto.	This is probably *R. odoratum* Wendl., the common very sweet-scented golden currant of gardens which often passes under the name *R. aureum* Pursh, a related species seldom cultivated and with little odor. See also **ginkaefolium** and **tenuiflorum.**
caucasicum	Vil.	Listed as *holosericeum* No. 7432 in Vilmorin's catalogue. This is probably *R. holosericeum* Otto and Dietr., a hybrid of *R. petraeum* and *R. rubrum.*
cynosbati* L.	Lon.	See **gracile.**
DIACANTHA Pall.		See **saxatile.**
floridum* L'Her.	Lon.	The name *R. floridum* L'Her., published in 1785, is a synonym of the much older R. *americanum* Mill., published in 1768.
fontanesii* Colla	Lon, Sto.	The name *R. fontanesii* Colla is a synonym of *R. odoratum* Wendl.
ginkaefolium*	do.	This is presumably a form of *R. aureum* catalogued for many years by Spaeth, a Berlin nurseryman, under the name *R. aureum ginkgifolium.*
GLUTINOSUM* Benth.		See **albidum.**
gordonianum* Lem.	Lon, Sto.	This is a well-known hybrid between *R. odoratum* and *R. sanguineum.*
gracile* Michx.	Sto.	Michaux's *R. gracile* is a smooth-fruited form of *R. cynosbati* L., but the plant that usually passes under the name *R. gracile* is *R. missouriense* Nutt., the Missouri gooseberry.
grossularia L.	Bru, Cop, Lon, Sto.	
heterophyllum Phil.	Lon, Sto.	According to Janczewski this is a variety of *R. punctatum* Ruiz. and Pav.
HOLOSERICEUM Otto and Dietr.		See **caucasicum.**
intermedium Tausch	Lon, Sto.	According to Dippel *R. intermedium* is a hybrid between *R. americanum* and *R. nigrum.*
longiracemosa Wilson.		Inoculated by Prof. W. Somerville, of Oxford.
macrobotrys Ruiz and Pav.	Lon, Sto.	
menziesii* Pursh	do.	This is a well-known gooseberry of southern Oregon and northern California, but the name has often been misapplied to other Pacific coast species. See **subvestitum.**
missouriense* Nutt.	do.	
nigrum L.	Bru, Chr, Cop, Lon, Sto.	See also **apiifolium.**
niveum* Lindl.	Lon, Sto.	
ODORATUM* Wendl.		See **aureum** and **fontanesii.**
orientale Desf.	Lon, Sto.	
oxyacanthoides* L.	do.	
parvifolia* Phio.	do.	This should be *parvifolium* Phil.
petraeum Wulf.	Cop, Sto.	See also **atropurpureum.**
propinquum Turez.	Vil.	According to Janczewski this is *R. warszewiczii* Jancz.
PUNCTATUM Ruiz and Pav.		See **heterophyllum.**

TABLE 1.—*List of species of Ribes infected with blister rust, etc.*—Continued.

Name of species.	Where seen.	Remarks.
Seen by the writer—Con.		
racemosa Wilson		Inoculated by Prof. W. Somerville, of Oxford.
rotundifolium * Michx.	Lon, Sto	
rubrum L.	Bru, Cop, Sto	
sanguineum* Pursh.	Lon, Sto	
saxatile Pall.	do	This is *R. diacantha* Pall.
setosum * Lindl.	do	
subvestitum *	do	The original *R. subvestitum* published by Hooker and Arnott is a synonym of *R. menziesii* Pursh., but other Pacific coast species of gooseberry have sometimes passed under the name of *R. subvestitum*.
tenuiflorum Lindl.	Lon	This is a synonym of *R. aureum* Pursh. The name has sometimes been misapplied to *R. gracillimum* Coville and Britton.
WARSZEWICZII Jancz.		See **propinquum.**
Seen by Prof. O. Juel:		
americanum * Mill.	Upsala	
aureum * Pursh	do	
biebersteinii Berl.	do	This is regarded by Janczewski as a variety of *R. petraeum* Wulf.
divaricatum * Dougl.	do	
divaricatum var. **glabrifolium.**	do	This is probably intended for *divaricatum* var. *glabriflorum* Koehne, a smooth-flowered form of *R. divaricatum* Dougl., a common northwest-coast gooseberry.
gordonianum* Lem.	do	
INERME Rydberg	do	See **oxyacanthoides nevadensis.**
multiflorum Kit.	do	
nigrum L.	do	
orientale Desf.	do	
oxyacanthoides nevadensis.*	do	This is *R. inerme* Rydberg, the wine gooseberry.
PETRAEUM Wulf.	do	See **biebersteinii.**
pinetorum * Greene.	do	
pubescens Sw.	do	This is doubtless *R. rubrum pubescens* Swartz.
rubrum L.	do	See also pubescens.
sanguineum* Pursh.	do	
sylvestre Mert. and Koch.	do	This is a synonym of *R. vulgare* Lam.
VULGARE Lam.	do	See **sylvestre.**

RELATION OF WHITE PINES TO EUROPEAN FORESTRY.

European forest conditions form a striking contrast to those in America. In Europe conservative methods of management and utilization have been in practice for centuries, whereas in America we are considering only the ways and means of applying such methods. Labor costs, though now abnormally high in Europe, as elsewhere, have usually been very low, a factor which has contributed largely to the success of forest practice abroad. With the development of forestry as a science, exotic tree species have been sought for study and experimental planting. There has been a continual search for species which would become readily naturalized and establish themselves under different conditions of planting and site. Trees from the New World were eagerly sought after, both for ornamental and forest planting. Many of the newcomers soon found a permanent place in the list of desirable species for use by the arboriculturist and the forester, foremost among which was *Pinus strobus*.

In Europe the eastern white pine of North America (*Pinus strobus*) is invariably called "Weymouth pine." According to Belon (*8*) this tree was growing in the royal nurseries at Fontainebleau, France, in 1553. If that is true, it is the earliest record of its appearance in Europe. It was not until after its introduc-

tion into England in 1705 and later into other European countries that the tree became prominent abroad. From the beginning its distinct and ornamental beauty interested foreigners (Pls. I and II). Gold and silver medals were offered for plantations of Weymouth pine in England by the Society for the Encouragement of Arts in 1765 (*1*). This tree is now well known abroad and is one of the most widely distributed of introduced American species. Unfortunately in several countries *Cronartium ribicola* has taken such heavy toll that some foresters are wary of planting it, while others have absolutely discontinued its cultivation.

White pine although widely distributed is not the commercially important forest tree in Europe that it is in America, for it is not a native species. The total area which it occupies is negligible in comparison with the forested areas of European countries. The ease with which the wood can be worked and its varied uses for joinery, pattern making, matches, and in shipbuilding for masts, yards, and deals brought imported white pine into much demand abroad. According to Laslatt, timber inspector of the British navy, when ships were built of wood "white pine served well for masts and bowsprits," but he says it was not strong enough for light spars subject to great and sudden strain. For such requirements it was surpassed in strength and durability by Oregon fir (*25*, p. 356–366).

To-day in Europe it is difficult to obtain white pine free from knots and sapwood. In England the value of the best quality is advanced to 6s. ($1.50) per cubic foot. During the war the timber controller fixed the maximum price at 9s. 8d. per cubic foot, or approximately $389.75 per thousand board feet (*20*).

Standing white pine has brought equally high prices. A 70-year-old plantation cut in Surrey during the war yielded a clear profit of $340 per acre. In the Vosges region of France 60-year-old plantations on optimum sites have yielded 68,590 board feet per acre, with a stumpage value of $44.53 per thousand board feet. Other plantations near Epinal in the French Vosges at the age of 55 years have produced a volume of 42,900 board feet per acre (fig. 1). In Germany, pure stands 104 years old yielded 81,538 board feet per acre, while stands 68 years of age produced 61,560 board feet per acre (*44*).

In volume production and rapidity of growth white pine ranks high. In the Vosges of France at 60 years it has shown a mean annual growth of 190 cubic feet per acre, a figure which has been equaled in Belgium. At Oxford, England, at 12 years the yield was 181 cubic feet per acre. It was outclassed in mean annual volume production by Douglas fir (*Pseudotsuga taxifolia*) from Vancouver, western hemlock (*Tsuga heterophylla*), western red cedar (*Thuja plicata*), and Sitka spruce (*Picea sitchensis*). The diameter growth of white pine, however, was good. Trees 12 years old with 3.2 inches average diameter at breast height were exceeded only by Vancouver Douglas fir with an average diameter of 3.4 inches (*38*).

A recent Belgian publication (*16*, p. 14) states that the only merit of white pine from its viewpoint is its large volume production and that its reputation as a tree with a future in Belgium has been overestimated. Bommer and Visart, on the other hand, credited white pine with being the one pine which up to the present has been cultivated successfully on the high plateau of the Ardennes (*6*). In

1911 an English writer said that the blister rust caused much damage to young trees, and it was not valuable enough to plant as a forest tree except on a small scale (*17*, p. 173). Similarly, Baltz in Ger-

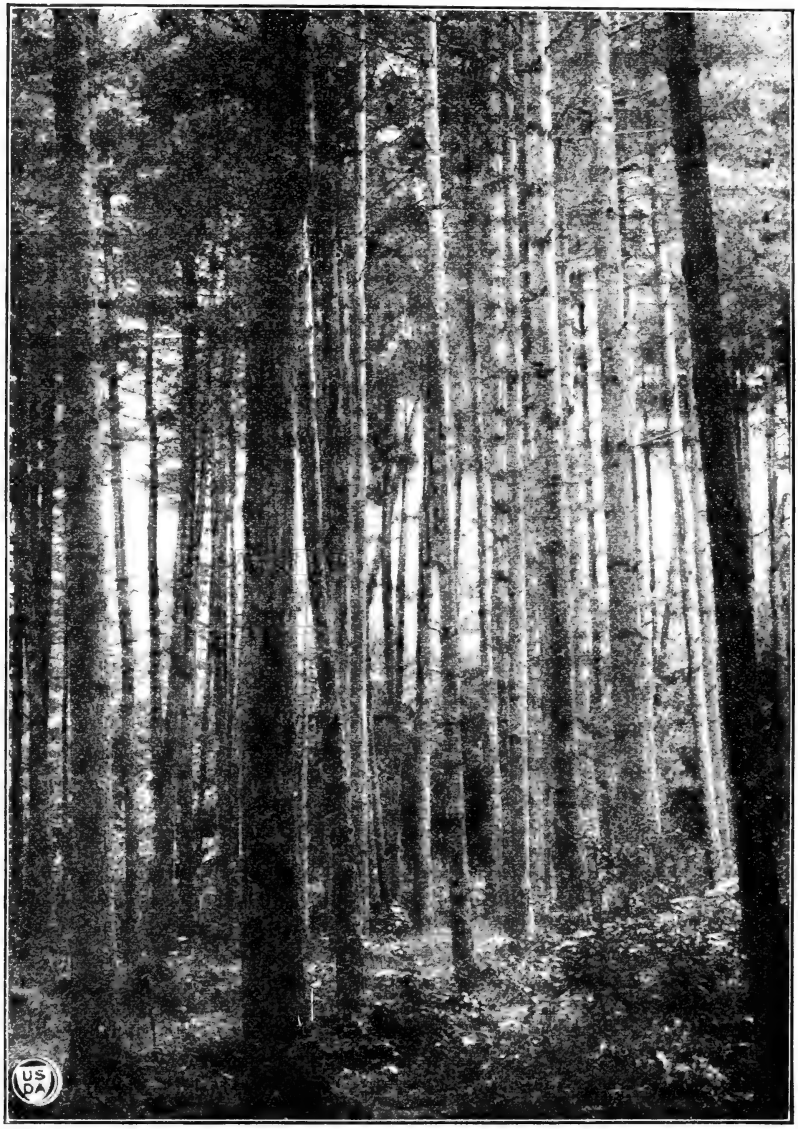


FIG. 1.—A 55-year-old white-pine plantation in the French Vosges, yielding 42,900 board feet per acre. Note the clean straight trunks of the trees. Such a crop is profitable, and there are many stands similar to this in the white-pine regions of northeastern America.

many suggested caution in planting white pine on a large scale (*4*). Henceforth, owing to the destructive power of the blister rust, white pine will be planted commercially less and less in Europe.

Other members of the American five-leaved pine group have been introduced into Europe, but only for ornamental and experimental planting. The sugar pine (*Pinus lambertiana*), the most valuable commercial timber tree on the Pacific coast, was introduced into England by Douglas in 1827 and later into other European countries. The western white pine (*Pinus monticola*), since its introduction into England by Douglas shortly after 1831, has been planted here and there in the British Isles and European countries as an ornamental tree (*12*). The limber pine (*Pinus flexilis*), a native of the Rocky Mountain region, has been planted scatteringly in Europe for ornamental and experimental purposes. Specimens are to be found in the British Isles, Belgium, France (fig. 2), Norway, Sweden, and Germany, but there are no extensive plantations. Others more rarely found are *P. albicaulis*, *P. balfouriana*, *P. monophylla*, and the Mexican white pine (*P. ayacahuite*). These trees have no commercial future in Europe, but are valued and sought continually for park and arboretum planting by tree enthusiasts. The Himalayan white pine (*Pinus excelsa*) and the Balkan white pine (*Pinus peuce*), both five-needle species, indicate favorable growth possibilities combined with more or less resistance to *Cronartium ribicola* and will undoubtedly become more popular abroad for forest planting.

IMPORTANCE OF CURRANTS AND GOOSEBERRIES.

Currants and gooseberries are universally grown in the cultivated areas of western Europe and are far more extensively used abroad than in this country, fulfilling many demands, such as making jellies, jams, pastries, and wine. Black currants (*Ribes nigrum*) generally predominate, although red currants, gooseberries, and ornamental species are common. Wild Ribes are usually limited to five species, *R. rubrum*, *R. nigrum*, *R. grossularia*, *R. alpinum*, and *R. petraeum*. In several countries only the first four occur, but not abundantly. This scarcity, however, is more than compensated for by the presence of the cultivated bushes, which are everywhere valued as a small fruit. Some 35 varieties of *Ribes nigrum* are described in the fruit catalogue of the Royal Horticultural Society.

Currant bushes frequently form the principal ornament in some of the gardens of European country cottages, and it is often customary to train the bushes against the walls of the house. There are nearly 200 varieties of gooseberries, including yellow, green, white, and red, which are made into jams and jellies. The wine made from the best yellow gooseberries has a flavor resembling champagne. Single gooseberries have weighed as much as $1\frac{7}{12}$ ounces (troy weight). At Duffield, near Derby, England, a bush 46 years old had a circular spread of 12 yards, and bushes at Chesterfield, England, trained against a wall, measured 50 feet from one extremity to the other (*3*).

The northernmost point at which *Ribes rubrum* grows is near Hammerfest, Norway, some 300 miles above the Arctic Circle. Other species, as *R. nigrum*, *R. grossularia*, and *R. alpinum*, are also found growing above the Arctic Circle.[9] Ribes species are essentially adapted to a cold moist region, and in Europe they usually do not

[9] Notes from the Botanical Museum, Christiania, Norway.

thrive in a warm dry climate. This distribution is well illustrated in France, where both wild and cultivated bushes are confined to the northern part of the country and the cooler regions in the vicinity of the mountains to the east and south. They do not occur in central France (*24*), where the climate is warm and dry. The Ribes

FIG. 2.—Limber pine (*Pinus flexilis*) of western North America, growing in the National Arboretum at Nogent sur Vernisson, Loiret, France. This tree, although thriving under its new surroundings, was attacked by the blister rust on two limbs, one located 2 feet and the other 4 feet above the ground.

of India, eight species in all, do not grow in the hot and dry areas, but in the Himalayan region (*19*) at altitudes between 7,000 and 13,000 feet. The Ribes distribution of the North Temperate Zone coincides closely with that of the five-leaved pines, affording optimum conditions for the development of the blister rust.

The universal cultivation of black currants in western Europe, although red currants and gooseberries are also grown, is the primary cause of the widespread distribution and seriousness of the disease in these countries. White pine is of less importance to the happiness and welfare of the average European than are these popular Ribes fruits which have been so carefully cultivated for centuries. Foresters have found a substitute for white pine in other fast-growing conifers, but no fruit to replace the currant and gooseberry. On account of the blister rust white pine can not be cultivated further at a profit, and the forester must respond to the popular demand to give up the exotic white pine rather than require the farmer and gardener to forego a profitable and widely grown crop. An excellent example of the damage done to white pine by the blister rust when black currants are near by to spread the fungus is shown in Figure 3.

DAMAGE TO EASTERN WHITE PINE IN EUROPE.

The earliest observation of damage to *Pinus strobus* by *Cronartium ribicola* is recorded by Hisinger in Finland, 1869 (*18*), who states that 30-year-old trees attacked on both the stems and limbs were being killed by the rust. Prior to 1870 the fungus had been reported in Denmark and later became so widely spread that in several places the cultivation of *Pinus strobus* was abandoned (*27*, p. 281). During succeeding years the fungus was discovered in other European countries, causing damage and killing trees. Information upon the subject is fragmentary, as no accurate records or data have been kept. Only meager notes were made concerning the occurrence of the fungus and the killing of the trees. It is quite natural that the European foresters should not regard the disease in the same light as American foresters, since, as previously stated, white pine is an introduced species of secondary economic importance. The fact that the tree is susceptible to the rust is sufficient in most cases to create prejudice against its further planting.

SWEDEN.

The general opinion expressed by the members of the forestry profession and of the Swedish experiment station is that the white pine is not adapted for planting in their country. The blister-rust attacks have been a potent factor in developing this attitude, for the pine has become infected wherever planted. A forester in northern Sweden states: "*Pinus strobus* is not a tree for my forest. It is quite impossible for me to raise it, for *Cronartium ribicola* [white-pine blister rust] causes great loss, particularly to young trees." Similar statements have been received from other parts of the country.

NORWAY.

Norwegian foresters have held white pine in very high regard because of its rapid growth and yield capacity, as well as its ability to regenerate naturally. To-day their attitude is very unfavorable, because of the destruction caused by the rust in their plantations. The Norwegian forest service has not used the species in its experimental plantations for several years and henceforth will not cultivate it. The few plantations made in the past have been thinned out by the disease until only a few white pines remain in the whole country.

One small 28-year-old experimental plantation at Jelsa had 100 per cent of the trees attacked by the blister rust and 6 per cent already destroyed. None of the remaining trees will make merchantable timber.

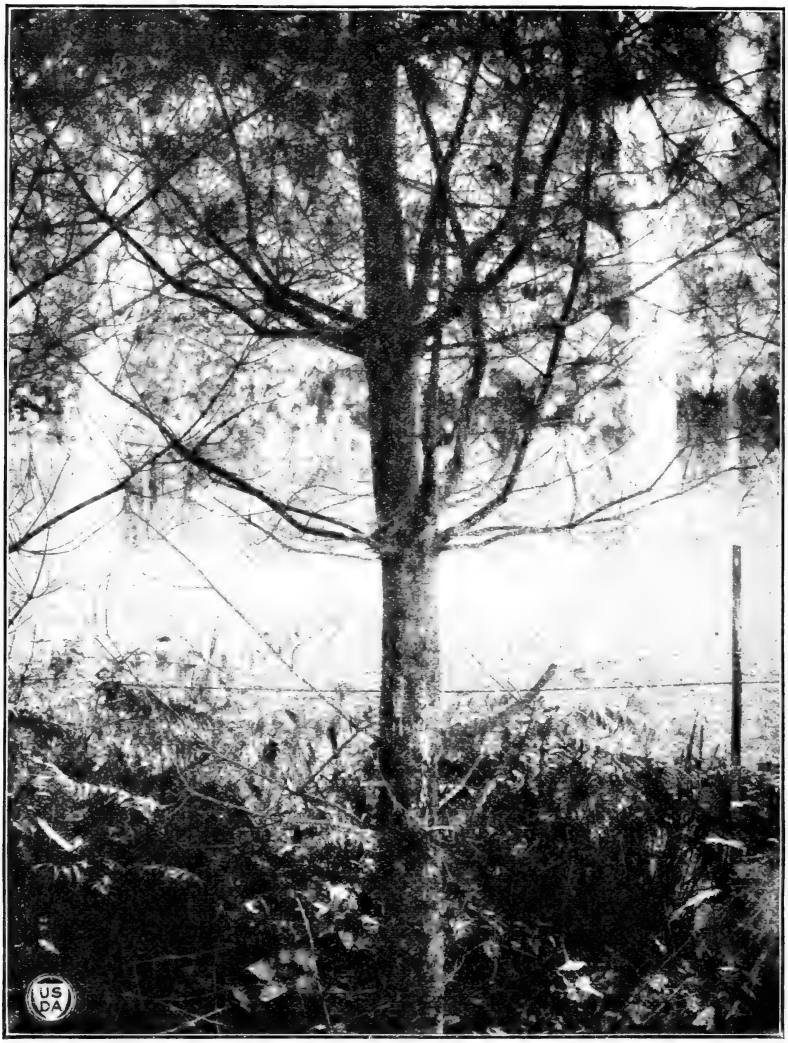


FIG. 3.—A white-pine tree growing near black currants at Bagley Wood, near Oxford, England. This tree illustrates the typical appearance of white pines in a 12-year-old plantation in which 95 per cent of the trees are attacked by blister rust. Each limb shown here, as well as the trunk, is diseased.

DENMARK.

The white-pine blister rust has been known on the island of Bornholm, Denmark, since 1890, when Rostrup collected the first infected twig at Almindingen.[10] Since that date the disease has become preva-

[10] Pathological collection, Royal Agricultural College, Copenhagen.

lent in plantations, doing such serious damage that the foresters have stopped planting the species. In one pine plantation in the Almindingen forest 91 per cent of the trees 20 to 30 years old have been attacked by the rust, and it is estimated that 75 per cent will be a total loss in 10 years, disregarding the probable damage from further infection. No merchantable product will be obtained, and the only revenue to be derived is from the sale of wood cut for fuel from the dead and dying trees, which barely covers the cost of cutting and is insufficient to pay for the original cost and maintenance of the plantation. The piling of the tops of white-pine trees felled because they were dead or dying from the blister rust and salvaged for fuel is illustrated in Figure 4.

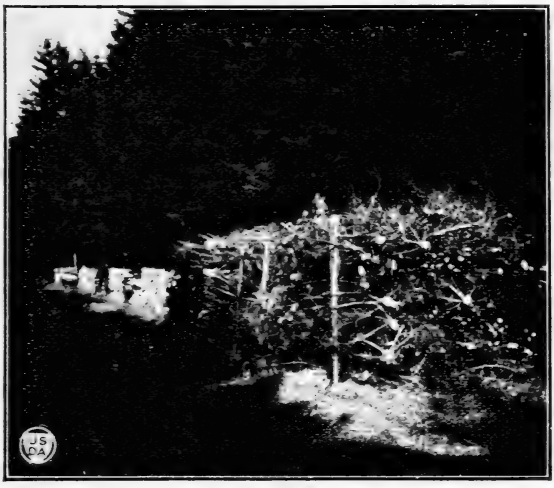


FIG. 4.—Salvaging the dead and dying white pines following a blister-rust attack on the island of Bornholm, Denmark. The tops and limbs, as well as the stems, are piled into cubic meters and sold for fuel.

In another pure stand of 24-year-old white pine, covering 16 acres, 90 per cent of the trees were attacked, and it is estimated that in 10 years 82 per cent of the trees will be dead. Out of 1,060 trees 20 to 30 years old examined in the Almindingen forest 90 per cent were diseased, and it is estimated that 78 per cent will be dead in 10 years. These figures represent the conditions in the entire stand. The actual loss can not be determined, because many diseased trees have already been cut. The typical condition of the white pines on the island of Bornholm, Denmark, where the destruction by the blister rust has been complete, is shown in Figures 5 and 6. The Danish foresters have a peculiarly descriptive term which they apply to the white pine. Their name for this tree is "Weymouthsfyr," but they commonly speak of it as "vemodsfyr" or the "melancholy pine," and this aptly expresses its appearance after it is attacked by the blister rust.

In the Corselitz forest, located in the northeastern portion of the island of Falster, the blister rust has so badly damaged the white-pine plantations that the cultivation of the species has been discontinued. Oak, a more profitable crop for this forest, is being used in some cases to replace the white pine (Pl. III).

BRITISH ISLES.

The damage to white pines in England has been serious. A study of a 12-year-old plantation at Bagley Wood, Oxford, revealed so much injury inflicted by the blister rust during the early life of the stand that it will be impossible to obtain timber of commercial value from the plantation. The occurrence of the disease here is interest-

FIG. 5.—Interior of a 24-year-old white-pine plantation at Almindingen, island of Bornholm, Denmark, showing the destruction caused by the blister rust, which has killed 32 per cent of the trees. The rest are dying from the disease.

ing, in that it showed a decrease in the amount of infection with the increase of the distance from Ribes to pine. Within 200 feet of the Ribes bushes (18 black currants, 3 red currants, and 7 gooseberries) 95 per cent of the trees were diseased (fig. 7). Farther away, at 570

FIG. 6.—Exterior view of the plantation shown in Figure 5. Even the trees showing the best height growth are badly diseased.

feet, it had decreased to 10 per cent, and at 1,096 feet no disease whatever was found.

In the Windsor Park forest at Surrey, 67 per cent of the white pines, approximately 20 years old, were attacked by the blister rust. Of these, 17 per cent had been killed and 25 per cent were in a dying condition. This plantation was made in mixture with *Pinus sylvestris* and other conifers, and the loss due to the disease is perhaps less than it would have been if the plantation had been purely *Pinus strobus*.

In 1896 *Pinus monticola* was observed to be fatally diseased in Scotland (*26*). A few years later some fine old trees were felled because of the damage inflicted by the rust. Hereafter in the British Isles white pine must be planted with caution and never in the vicinity of black currants, as has been the custom in the past. It will be

FIG. 7.—A 12-year-old white-pine plantation at Bagley Wood, near Oxford, England, in which 95 per cent of the trees are attacked by the blister rust and 84 per cent are in a dead or dying condition, within 100 feet of where 18 black-currant bushes were growing.

well also to plant white pine in mixture with other conifers, rather than pure, in order to provide all possible protection from the screening afforded by other trees.

FRANCE.

French foresters minimize the menace of the blister rust to their white-pine plantations and maintain an optimistic viewpoint, because the old trees on a casual inspection do not appear to be seriously injured. This is not true for the young age classes. As far as could be learned, the disease has been known on pine in that country only since 1890 (*34*, p. 342). It is present and destroying natural reproduction in the Vosges district, where the writer found clumps in which 49 per cent of the regeneration was diseased (fig. 8). After the felling of the mature stands the damage will be more striking in the young growth. If new plantations are made the disease is certain to attack them severely before they are 15 years old; that is, assuming that the

Ribes bushes are not removed as an act of protection, which seems quite unlikely. Plate IV shows a 50-year-old tree in the communal forest near Epinal, France, killed as a result of severe crown infection by blister rust. Inspection of wind-thrown trees in another section of the same forest revealed many infections and conclusively proved that no tree is too large to be attacked and killed by this disease.

BELGIUM.

The damage in Belgium has been large, but few detailed data are available as to the actual extent of destruction. At one time the future of white pine in that country was regarded as particularly bright because of the success with which it had been grown in the Ardennes. In fact, it is the only pine which has been successfully

FIG. 8.—Natural regeneration of white-pine trees 3 to 15 years old which have grown in an opening made in the overwood of pine and spruce. In a sample plat 25 feet square 49 per cent of the trees were infected with blister rust. Diseased twigs are marked with pieces of paper, and the tree with the cap on the trunk is dying.

cultivated in the high plateaus of that region. This opinion has been altered, owing to the damage done by blister rust. In an 18-year-old plantation studied by the writer, 50 per cent of the trees have been killed and 53 per cent of those remaining were diseased. The forester in charge of another severely infected plantation said he considered it best to destroy the entire lot and replant with another species, since the white pine could not be grown to commercial size. In the opinion of the Belgian forest service it can not afford to plant the tree extensively because of its susceptibility to attack and damage by *Cronartium ribicola*.

The figures in Table 2 accompanying were obtained from studies made in typical infected white-pine stands for the purpose of showing the average diseased condition of the entire plantation. They illustrate representative conditions in the countries visited. In most

REMNANT OF A 20-YEAR-OLD WHITE-PINE PLANTATION, CORSELITZE, DENMARK.

Each of the 200 remaining trees is diseased with blister rust on the stem or limbs or both. The most severely infected trees have been felled. Those left are now used as a cover crop for the pedunculate oak, *Quercus pedunculata* Ehrh. As soon as the oak becomes well established all the white pines will be cut.

WHITE PINES IN A COMMUNAL FOREST NEAR EPINAL, FRANCE.

The 50-year-old tree bearing the cap has been killed by the white-pine blister rust, while other trees in the opening in the background have serious crown infections.

cases the site chosen for the plantation was favorable to the growth of white pines. The Windsor Park woods, England, were too sandy for its best development, and the location at Almindingen, island of Bornholm, Denmark, was too wet.

TABLE 2.—*Summary of typical European conditions with respect to the infection of pine trees with blister rust.*

Country and locality.	Area studied.	White-pine (Pinus strobus) trees examined.								Black currant (Ribes nigrum).	
		Average height.	Number.	Attacked by rust.		Killed by rust.		Dying from rust.		Distance from pines.	Number.
				Number.	Per cent.	Number.	Per cent.	Number.	Per cent.		
England:	*Acres.*	*Feet.*								*Feet.*	
Oxford	2	20	111	105	95½	21	19	73	65.7	190	18
Windsor Park	25	25	394	67	17	17	4.3	17	4.3	1,760 to 4,600	100
Norway:											
Jelsa	1½	35	159	159	100	107	67	52	32	150	10
Fjosanger	¼	25	20	20	100	5	25	15	75	500	12
Sweden:											
Atvidaberg	1	30	30	25	83	.....	.....	3	10	3,500	150
Denmark:											
Almindingen	15	20	517	464	90	168	32	184	33	820	15
	16	35	543	493	91	94	17	245	45	3,000	50
France:											
Lesbarres	5	15	31	5	16	.....	.....	4	13	1,600	35
La Mouche, Epinal	4	10	63	31	49	7	14	.....	.....	2,500	50
	6	12	75	27	36	.....	.....	7	1	2,500	30
St. Oger	2	7	135	26	19	6	4	.....	.....	3,300	10
Deyvillers	2	18	89	42	47	7	7	.....	.....	870	10
Belgium:											
Gedinne	¼	25	41	27	65	.....	.....	19	46	3,160	3
	4½	20	62	62	100	6	9	51	80	524	5
	2	12	37	21	57	.....	.....	.....	.....	430	15
Total or average.	86½	21	2,307	1,574	68	438	19	670	29	1,653 to 1,843	493

The European situation may be briefly stated as follows: The white-pine plantations in some countries are disappearing as a result of the damage by the rust, and foresters quite generally express the opinion that the loss resulting from the disease is too large to permit raising the species at a profit. The white-pine plantations are being replaced by other foreign conifers of good growth rather than protecting them by destroying the Ribes.

CONTROL MEASURES RECOMMENDED IN EUROPE.

When foresters and pathologists recognized the damage being done to the white pine by the rust they began to consider means of combating it to save their plantations and ornamental trees from destruction. Although in Europe the white pine is an exotic tree, *Cronartium ribicola* is believed to be a native fungus indigenous to Siberia. The exact reverse of this condition applies to the United States, where the fungus is rapidly becoming too well naturalized in its new environment.

For at least 30 years European writers have recommended methods of control, though rather indefinitely, and have even proposed curative treatment for infected trees. The writer found that control measures were rarely put to a practical test. The seriousness of the disease is fully realized, and its life history is well known, but

it took some years for it to become sufficiently well established to attract much attention. The most effective control method, consisting of Ribes extermination in the neighborhood of white-pine plantations, has seldom been practiced. Popular opinion favors saving the black currants rather than the exotic white pine, because the people have a greater appreciation of their native currants than of a foreign tree.

SWEDEN.

Among the earliest recommendations for control are those made by Prof. Jakob Eriksson in Sweden in 1890 (*13*). He informed the writer that the control of the fungus by the removal of the Ribes had not been undertaken in Sweden. For some years white pine had been grown in nurseries at Djurgarden, Stockholm, but its cultivation was stopped in 1897 because of the increasing loss from *Cronartium ribicola*. At least 50 per cent of the seedlings between the ages of 3 and 5 years became diseased. All such infected stock was pulled out and burned, and Professor Eriksson gave orders that no white pine from the nursery was to be shipped to other parts of the country.

Black currants and gooseberries were grown near the white-pine beds, the former species showing severe infection annually. The significant feature is that the cultivation of white pine ceased, while that of Ribes continued. A few old trees planted in the park at Djurgarden early in the nineteenth century became infected in the crown and on the side limbs. These trees were carefully treated by removing the diseased limbs, so that to-day they still survive, although somewhat lacking in natural symmetry because of the pruning away of the infected branches.

NORWAY.

A Norwegian writer, Schøyen, in 1895 recommended growing the Ribes and pine apart from each other (*39*, p. 56). This advice was followed in 1904 by Director Saxelund, of the Norwegian forest service, who ordered that no more *Pinus strobus* should be planted in the Government nurseries at Sandnes.[11]

DENMARK.

Rostrup, in Denmark, 1889, issued a bulletin to the forest guards dealing with the dangerous tree diseases, in which he advised that Ribes and white pine should always be separated (*35*, p. 11). The only case of the removal of Ribes from the vicinity of a white-pine plantation in Europe was brought to the writer's attention at Corselitz, Denmark. The plantation referred to was located near the cottage of a forest guard, and 20 years ago an order was issued that no Ribes should be grown in the cottage garden. On what authority the order was issued is not known, but it is believed to have come from Rostrup. The removal of the black currants effectively checked the spread of the rust, and to-day the trees are thrifty. In contrast to this, consider the appearance of the 34-year-old white-pine plantation suffering from severe crown infection shown in

[11] Oral information from Skogforvalter A. Jenssen, Stavanger, Norway.

Figure 9. No control measures were attempted here, the result being that 90 per cent of the trees are diseased.

FRANCE.

French foresters to date have given the fungus little attention, for white pine is of secondary importance to them, and they have been concerned with forest problems of a nature more vital to their country. The writer found no case where the uprooting of Ribes had been attempted or silvicultural methods undertaken to control the disease in France. The blister rust is nevertheless working destructively in their plantations. Figure 10 shows a 17-year-old stand wherein 52 per cent of the trees are attacked so seriously that it is doubtful whether they will ever reach maturity.

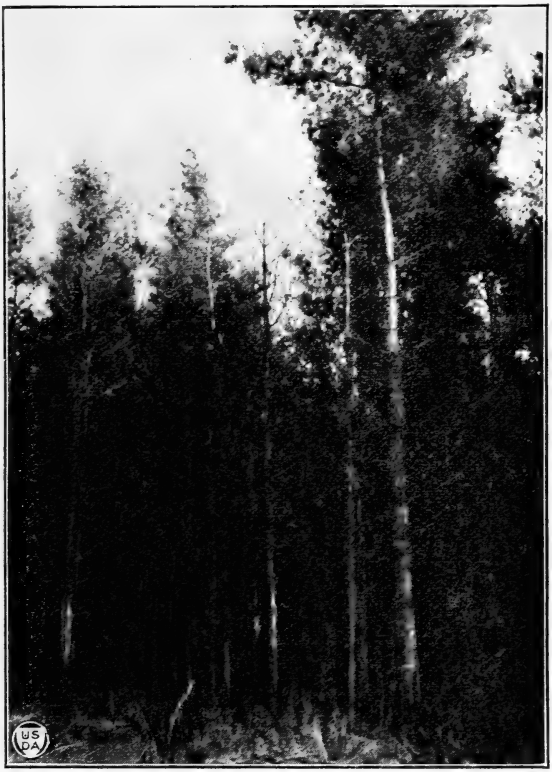


FIG. 9.—A 34-year-old white-pine plantation at Almindingen, island of Bornholm, Denmark, in which 90 per cent of the trees have been attacked in the crown by the white-pine blister rust. Many of the trees killed by the rust have been felled. Some of the diseased trees had their weakened tops broken off by the wind.

BELGIUM.

Notable among recent Belgian investigators dealing with the blister-rust fungus are Professor Marchal; Professor Bommer, of Brussels; Forest Inspector Pechon; and Professor Quairiere, of the research station at Groenendael. With the exception of the experiments made with fungicidal treatment at the experiment station at Groenendael, the writer saw no cases where the suggested control methods have been adopted. Bommer emphasized the need of exterminating the fungus in the nurseries by destroying infected trees. Pechon in conversation with the writer placed little faith in the treatment with chemical solutions to check the development of the fungus and strongly advised the removal and burning of infected trees. Such a practice, however, is futile unless the currants and gooseberries in the locality are also destroyed.

It is a common practice in many European nurseries to grow white-pine stock and Ribes near each other. After attention was called to

the blister-rust menace several of the nurseries of Belgium and France specializing in conifers for exportation discontinued the growing of black currants, since this species caused the most damage to pine. In other nurseries where the currants are of major importance the cultivation of five-leaved pines has been abandoned. The nursery beds shown in Figure 11 are in one of the largest of the French forest nurseries, situated near Orleans. These were started since the war and contain Austrian and Scotch pines, but no American five-needle pines, the growing of which was discontinued.

BRITISH ISLES.

British foresters declare the rust to be altogether too prevalent, but have made no efforts to control it. The fungus has raised more interest and concern among fruit growers than it has among the foresters, because the former feared a decrease in their black-currant crop, entailing financial loss.

FIG. 10.—A 17-year-old white-pine plantation near Epinal in the French Vosges. Blister rust has attacked 52 per cent of the trees. This entire plantation is exposed to further infection from black-currant bushes growing 600 feet distant. It is doubtful whether merchantable timber will ever be obtained from it.

Trials made at Oxford, England, to check the rust by spraying Ribes proved quite unsuccessful (*2*, p. 24). Reference to the spraying of young pines with a fungicide is made in the Quarterly Journal of Forestry (*5*), with a statement that in a Belgian nursery seedlings sprayed with a 1 per cent solution of potassium permanganate had been effectively protected. Chemically treating diseased parts of stem or limb may retard the development of the disease, but results thus far obtained are rather uncertain. Silvicultural methods will never control the fungus as long as Ribes bushes are permitted to grow in the neighborhood, but the opinion prevails that such methods may slightly decrease the amount of infection through better aeration and the entrance of more sunlight into the stand, especially if it occupies a moist site. If the black currants had been removed from the neighborhood of the plantation at Oxford, it would not be in its present poor condition (fig. 12).

Control of a forest disease on as extensive a basis as the blister-rust work in the United States has no parallel in foreign forest practice and presents a striking contrast to the limited measures of con-

trol which they have applied to small groups or isolated ornamental specimens. Strenuous efforts to control the blister rust wherever it occurs are not made in Europe because the tree lacks the commercial status necessary to warrant such action.

No European country has carried out a definite scheme of study for the control of *Cronartium ribicola* covering a number of years. The work done in the past has been conducted by individual initiative and interest, the investigators working independently and in some cases apparently unaware of each other's activities. The work in Sweden by Eriksson was prompted by a popular fear lest the disease on *Pinus strobus* should prove a menace to the native *Pinus sylvestris*, the principal forest timber species.

GERMANY.

Klebahn's work in Germany was undertaken from a purely scientific viewpoint. He paid little attention to the practical side of the question when he saw that the foresters were not concerned about it. When the United States restricted the entry of five-needle pine nursery stock in 1912 because of the fungus, the nurserymen took a greater interest in the subject. Large nurseries situated near Halstenbeck, Germany, conducting an extensive export trade were particularly affected by this restriction. They called upon Klebahn to witness that their stock was free from blister rust, which testimony he was bound to decline, since the fungus is difficult to detect on seedlings. To Klebahn's knowledge measures against the disease have not been taken anywhere in Germany, since *Pinus strobus*, aside from the nurserymen's point of view, is of small economic importance. It is said that in the municipal forest of Heidelberg there are mature white-pine plantations covering nearly 150 acres. This is probably the largest single plantation of the species in Europe. Professor von Tubeuf, who has made a careful study of the blister rust in Germany, expects that in the future white pine will be grown less and less in that country.[12]

FIG. 11.—A large forest-tree nursery in France. The seed beds, started since the war, contain Austrian pine, Scotch pine, and Norway spruce.

SIGNIFICANCE OF EUROPEAN EXPERIENCE TO AMERICA.

The observations made abroad on the susceptibility of sugar pine, western white pine, and the limber pine show that these species are as readily attacked and as severely damaged by the white-pine blister rust as is the eastern white pine. Laurie found western white pine

[12] Correspondence with Professor von Tubeuf, 1920.

fatally attacked at Murthly Castle, Scotland, in 1893, although no record of the occurrence was published until 1898 (*26*). The rust so badly damaged and disfigured the beautiful ornamental specimens

FIG. 12.—Interior view of a white-pine plantation in Bagley Wood, near Oxford, England, in which 84 per cent of the trees are in a dead or dying condition. Every tree shown is diseased, and the tree in the foreground produced spores on October 15, 1920. Black currants were growing only 100 feet away.

growing in the Murthly Castle Park, which had reached a height of 60 feet, that it was necessary to cut them down. To-day, only one tree remains of the original group of 50. This tree, having a diameter of 26 inches and a height of nearly 90 feet, is probably the

largest specimen of western white pine in the British Isles. It, too, is being killed by blister rust. In young plantations of western white pine at Balmoral Castle, Scotland, the blister rust is gradually working with telling effect. Neger reports this species as being attacked by the rust in Germany (*30*, p. 280).

The California sugar pine was found diseased in Scotland, France, and Belgium, and is reported from Germany.[13] A most striking example of damage done to a single tree was observed at Murthly, Scotland. An arboretum specimen, 20 years old, with a height of 20 feet, is so heavily attacked on every limb to a height of 8 feet from the ground and so severely constricted on the stem that it is practically worthless. The late Sir Edmund Loder, of Horsham, Sussex, England, stated in correspondence that young sugar pines on his estate were attacked and killed by the rust. The appearance of infected trees in Belgium and France indicates that this species is highly susceptible.

The limber pine was seen diseased in Norway, Sweden, and France, and Tubeuf states that it is infected in Germany (*42*). One of the most interesting cases of damage to the limber pine by the blister rust was seen at Softeland, near Bergen, Norway. In a plantation of 7-year-old trees numbering 300, each tree was diseased and one-third of the number killed. The infection may be directly attributed to black-currant bushes growing in a garden 650 feet distant. At the Alnarp Forest nursery in Sweden 100 seedlings 6 years old were destroyed in 1920 because they were found to be diseased. A few younger seedlings remaining in the nursery (fig. 13) had developed the disease in only two cases. In the National Arboretum at Nogent sur Vernisson, France, 12-year-old trees of this species have been killed by the disease (fig. 14).

The Mexican white pine is heavily infected, the disease being found on this species in Belgium and England. Extensive plantations of these trees do not exist abroad, since they have been planted chiefly for ornamental purposes. The severity with which the fungus has attacked them and its rate of development clearly demonstrate that they are readily susceptible.

These facts are of special significance to the United States and sound a clear call to action. The recent discovery of white-pine blister rust in British Columbia and Washington and the widespread abundance of wild currants and gooseberries in the Pacific coast and Rocky Mountain regions (there being about 60 species) place the valuable western five-needle pines in an extremely hazardous position. Furthermore, climatic conditions of the West appear to be favorable to the spread and development of the fungus. There is a striking resemblance between the climate of western Norway, where the disease worked destructively in white pine and limber pine, and the northwest coast of the United States. Observations in Norway on the growth of the Douglas fir and Sitka spruce show that these indigenous species grow admirably in that region, thus giving evidence of the similarity of the climate of the west coast of Norway and of America. They give such promise of excellent volume production that in the future these trees will undoubtedly play an important rôle in the forestry practice of that country.

[13] Correspondence with Professor von Tubeuf, 1920.

During the wet summer of 1917 (*2*, p. 24) the blister rust developed so heavily and so seriously on cultivated black currants in England that nurserymen became alarmed and feared a decided setback to their currant crop because of defoliation of the bushes.[14] A climatic condition favorable to the spread of the rust on the currants results in an increased amount of pine infection. French

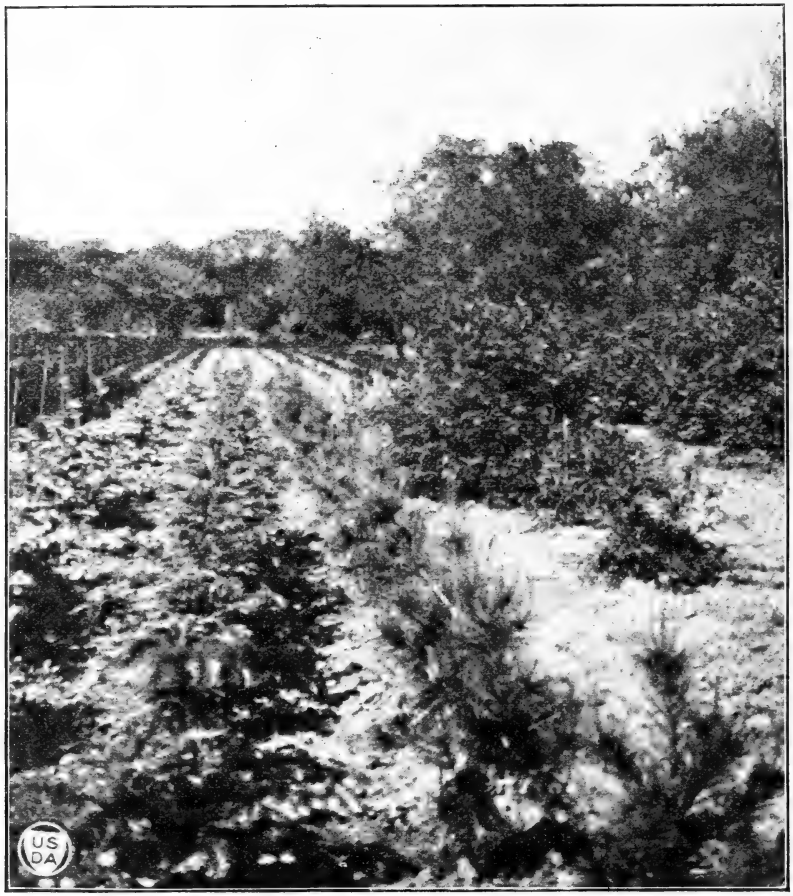


FIG. 13.—Limber pine (*Pinus flexilis*) growing in a nursery at Alnarp, Sweden. Blister rust first appeared here in 1920, at which time 100 seedlings 6 years old were destroyed. The young trees were growing within 300 feet of black currants and gooseberries. This shows the results that may be expected from an exposure of this species to the white-pine blister rust.

foresters maintain that the disease is much more abundant during a wet year than in a dry one.[15] A similar opinion is upheld by members of the Belgian forest service. In the western United States the two factors of an abundance of wild currants and gooseberries and a climatic condition favorable to the fungus will work together to the detriment of the five-needle pines. European cli-

[14] Notes obtained from Kew Garden Laboratory, through the courtesy of Dr. A. D. Cotton.

[15] Oral statement to the writer.

matic conditions suitable to the growth of the five-needle pines were found favorable to the development of the blister rust.

ECONOMIC ASPECTS OF THE BLISTER-RUST PROBLEM.

The problem of controlling the blister rust in eastern North America is distinctly an economic one, and the practical application of forest pathology must aid in the protection of a basic industry by maintaining forest production. The task at present has developed beyond protecting merely a restricted area; it involves the entire country west as well as east. It has been positively demonstrated in eastern North America that this disease can be controlled at a reasonable cost by uprooting all currant and gooseberry bushes within 900 feet of white-pine forests. The blister rust can not be eradicated from North Amercia, but the local destruction of currants and gooseberries prevents damage to pines within the control area.

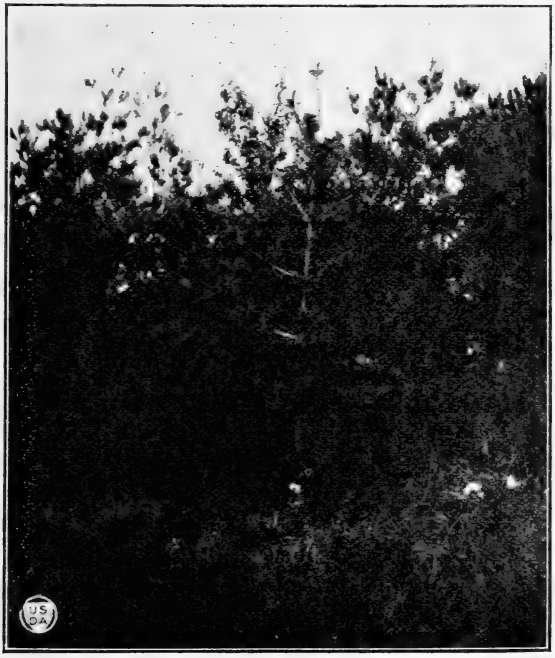


FIG. 14.—Limber pine (*Pinus flexilis*) in the National Arboretum at Nogent sur Vernisson, France, dying from a blister-rust attack. The 12-year-old tree in the center was much weakened in 1920, as indicated by the yellowing and shedding of the needles, and died the following year. This species appears to be a ready victim to the rust.

The value of the commercial eastern white pine alone amounts to $276,000,000 [16] an asset well worth insuring against the rust. Recent careful studies made on the rate of spread of the fungus in New York, New Hampshire, Vermont, and Massachusetts show 15 per cent general infection. This is only the beginning of the invasion, for the disease is comparatively young here, having been only 25 years in the country and not imported to any appreciable extent until 1909. During the next decade it will gain impetus, spread with ever-increasing force, and impress its seriousness upon the public mind. The crux of the situation lies in the fact that the young white-pine growth which should become the commercial stands of the next 30 years will be severely hit. Clearly the control of the disease by the removal of currants and gooseberries in the East must be vigorously pursued.

[16] Estimate of the United States Forest Service.

WESTERN NORTH AMERICA.

One of the grave problems now confronting the Federal and State Governments is the safeguarding of the five-leaved pines of the West from this European pest. Now that the disease has made its appearance in British Columbia and Washington, what will be the result? The final outcome is difficult to forecast, but it is certain that the western five-leaved pine forests are in grave danger. Observations made in Europe upon the susceptibility of sugar pine, western white pine, and limber pine to the fungus showed that these trees are as readily attacked and as severely damaged by the white-pine blister rust as is the eastern white pine. It means that $228,400,000[17] worth of growing timber is to become the prey to a very insidious and dangerous disease. A widespread attack in this region is imminent and threatens to bring immeasurable loss to private owners as well as to the Federal Government. To judge from the severity of the disease on these species of pines in Europe, it is no exaggeration to predict that the presence of the blister rust in the Northwest threatens the future position of these valuable pine species in the timber markets of the world.

DECIDED STEPS OF ACTION NECESSARY.

The action demanded by present conditions in order to control the blister rust is summarized as follows:

(1) Energetic control of the disease in the East by the general eradication of currants and gooseberries in pine-growing sections.

(2) Prompt and decisive action to control the disease in the West.

(3) Eradication of the cultivated black currant, the most susceptible alternate host of the blister rust and the most active agent in its spread and establishment.

(4) Strict adherence to and prosecution of the quarantine laws prohibiting the shipment of five-needle pines and currant and gooseberry plants from infected territory. Also the continued enforcement of the quarantine placing an absolute embargo on foreign nursery stock, thus preventing the entrance of the blister rust and other pests from foreign countries. Conditions demand such action.

The scope of the problem is more than regional or national; it is international. Neither evasion of the quarantines nor laxity in the prosecution thereof can be permitted. The liability is large and the hazard great.

SUMMARY OF THE BLISTER-RUST SITUATION IN EUROPE.

The white-pine blister rust was first discovered some 65 years ago on pine and currants in the Baltic Provinces of Russia. Six years later it was seen to attack seriously 30-year-old white-pine trees in Finland and was marked as a dangerous tree disease. It is difficult to state where the disease originated, but the facts available to the writer indicate that Russia was the original home and *Pinus cembra* its host. From there it migrated and gradually spread over western Europe.

Its occurrence was noted with increasing frequency from 1880 to 1900, particularly in those countries, such as the British Isles, Denmark, Germany, and Sweden, in which plant pathology is carefully

[17] Estimate of the United States Forest Service.

studied and in which tree species from America were being continually sought for experimental forest planting and ornamental purposes.

The first known occurrence of white pine in Europe was in the Royal Nurseries at Fontainebleau, France, in 1553. It was not extensively planted until after its first introduction into England in 1705 and later into other European countries. From the outset it gained the high regard of arboriculturists and foresters abroad because of its distinct ornamental beauty and the excellence and suitability of its wood for many purposes. To-day it is well known in Europe, having been one of the most widely distributed of the introduced American trees.

Nurseries undertook the cultivation of white-pine stock for domestic sale and for export trade in localities where currant and gooseberry bushes were present, a practice which contributed largely to the spread of the fungus in Europe and America. As the demand for nursery stock increased, European nurseries, particularly those of Germany and France, undertook to meet the requirements. Until 1912 they could raise and ship white pines to America without restriction. This policy resulted in the importation of the white-pine blister rust into America about 1898, and this plague gradually spread through the northeastern white-pine region. Later, probably about 1910, it was introduced into British Columbia and has recently reached Washington.

The spread of the blister rust followed the increase in the distribution of white pine in European countries, reaching even to the northernmost plantings of the species in Norway. Eastern white pine is not the only member of the American five-leaved pine group attacked by the blister rust. Other five-leaved pine species introduced into Europe for ornamental and experimental planting have likewise become affected. Prominent among these are the California sugar pine, the western white pine, the limber pine, and the Mexican white pine. These species appear to be as readily susceptible as the eastern white pine.

Cultivated black currants and gooseberries, especially black currants, are very plentiful in European countries, and through them the disease is perpetuated with ever-increasing volume. Wild currants and gooseberries are very limited as to the number of species, and the bushes are scarce in the forests. The control of blister rust as a forest-tree disease does not appear to have been seriously attempted abroad. A few efforts have been made to check the fungus on individual ornamental trees by removing the infected parts or treating them with chemical solutions. The wholesale removal of cultivated and wild currants and gooseberries is not practiced, not because of lack of knowledge of the damage done by the diseased currants, but because the currants are of more value to the people than the foreign white pine.

The blister rust is gradually driving the white pine out of Europe. Unfortunately, the stands are gradually disappearing in Europe because of damage by the blister rust. Foresters generally are expressing the opinion that the damage done by the fungus is too large to permit raising the species at a profit. Often over 90 per cent of the trees in plantations are infected, and frequently one-third have been killed by the blister rust. Mature trees also are fatally attacked, as

shown on eastern white pine in Sweden and France and western white pine in Scotland. Many European foresters have been enthusiastic over the future prospects of white pine in their countries, believing that it would come to occupy an important position in their system of management and be regarded as an indigenous species. As shown by its growth abroad it has excellent volume production, regenerates well (fig. 15), and is not exacting as to soil and moisture requirements. Such an optimistic outlook was held by foresters in Denmark, Belgium, and Norway, while the Germans had faith enough in the productive capacity of the species to plant considerable areas with white pine.

FIG. 15.—Natural white-pine reproduction in the communal forest of La Mouche, Epinal, France. In this part of the forest 36 per cent of the young trees were attacked by the blister rust, thus greatly reducing the probability of a future crop.

Other foreign conifers, such as Douglas fir, Sitka spruce, and Japanese larch, will gradually replace the disappearing white pine. Himalayan and Balkan pine will also come into more extensive use for forest planting.

EUROPEAN EXPERIENCE A WARNING TO AMERICA.

This disease is a most dangerous forest enemy. It readily kills mature trees, but the greatest menace is in sweeping out of existence the young pine stock of to-day which is to become the mature timber of to-morrow. Although it is slow in developing, it is nevertheless constant in action and certain in destruction, undermining the very security of our forest capital, without which continued forest production is impossible.

Blister-rust control is a national problem. It is necessary to protect a resource so essential as white pine for economic and industrial development. Simple and practical methods are available to any pine owner in the eastern United States which enable him to safeguard his pines from this disease. The blister rust is spreading into the western white-pine and sugar-pine forests and threatens the commercial extinction of these species. Vigorous action is required to develop and apply measures that will minimize the damage in the West.

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WHITE-PINE BLISTER RUST may destroy much of the white pine of the United States. This destructive disease probably had its original home in Asia, later reaching Europe. It was introduced into America during the years 1898 to 1910. European and American investigations indicate that this rust can not spread direct from pine to pine and that an intermediate stage of development on currant and gooseberry bushes is necessary before it can harm the pine. Studies of the disease in this country showed that the distance to which currant and gooseberry bushes infect pines is comparatively short. This knowledge is the basis of the local control work in the United States, which was begun experimentally in 1916. These experiments prove that under ordinary forest conditions in the eastern United States a stand of white pine is subject to little or no damage from the rust if there are no European black currants growing within a mile and no other currant or gooseberry bushes within 900 feet. European black currants are dangerous to pine at greater distances than other species because they are more susceptible to the rust and produce a much larger volume of spores per unit of infected leaf surface.

The purpose of the study in western Europe in 1919-20 was to determine how destructive the blister rust had been to American white-pine species planted abroad and what steps, if any, had been taken to combat this disease in foreign countries that would be of practical value in controlling the disease in the United States. It was found that cultivated black currants and gooseberries, especially black currants, are very abundant in Europe and popularly considered of more value than the foreign white pine. Consequently these bushes have not been removed from the vicinity of the white-pine plantations, and the blister rust is gradually driving these trees out of Europe by destroying such a large percentage that it is unprofitable to cultivate the species. White pine is being supplanted by other foreign conifers, such as Japanese larch, Douglas fir, Sitka spruce, and Balkan pine.

Very recently the blister rust has been found on the Pacific coast in Washington and British Columbia. This discovery is a matter of great concern, since there are seven different white-pine species in the West and the country's greatest white-pine resources are centered in the western white-pine and sugar-pine forests. Western white pine and limber pine apparently are more susceptible to the blister rust than eastern white pine. Sugar pine is also highly susceptible. To delay the spread of the rust through the eradication of cultivated black currants and quarantine enforcement and the development of practical local control measures adapted to the conditions found in western forests are the only alternatives to the ultimate extinction of the most valuable commercial pine-timber species of the West.

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