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White Pine Blister Rust

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White pine blister rust is a fungus disease that attacks and destroys white pines (the 5-needled pines) in the United States. This virulent disease is well established throughout most of the range of eastern white pine (*Pinus strobus* L.). It is widespread in stands of western white pine (*P. monticola* Dougl.) in Oregon, Washington, Idaho, and Montana, and in stands of the highly susceptible sugar pine (*P. lambertiana* Dougl.) in southwestern Oregon and northern California. The rust is causing severe damage to whitebark pine (*P. albicaulis* Engelm.) and limber pine (*P. flexilis* James) in some of the high mountain areas of the West, where these pines have great value for watershed protection and recreation. This leaflet presents useful information primarily for the large number of workers in control organizations.

Blister rust is caused by the fungus *Cronartium ribicola* Fischer. This is one of those organisms that need two alternate hosts to survive. It spends part of its life on pine trees, the other on plants of the genus *Ribes* (pronounced *rye-bees*), which includes gooseberries and currants.

Blister rust is not native to North America. It is generally believed that the original host of the rust was Swiss stone pine (*Pinus cembra* L.) in northern Asia.

The earliest report of blister rust on our native eastern white pine came from Europe in 1854. The rust was found in the Baltic provinces of Russia where white pines had been introduced from America. By 1900 the rust had spread over most of Europe.

The disease was first found in North America at Geneva, N.Y., in 1906, on cultivated currants. These currants were promptly destroyed, in hopes of eradicating the disease. But 3 years later the disease was found on seedlings in new plantations of white pine. Nursery stock of *Pinus strobus* had been imported from European nurseries and planted at several widely dispersed locations in the Northeastern and Lake States and in eastern Canada. It is now believed that the disease may have entered North America as early as 1898.

At first, State agencies destroyed all the rust-infected trees they could find. But by 1913 the disease had spread from the plantations into natural white pine stands. It was

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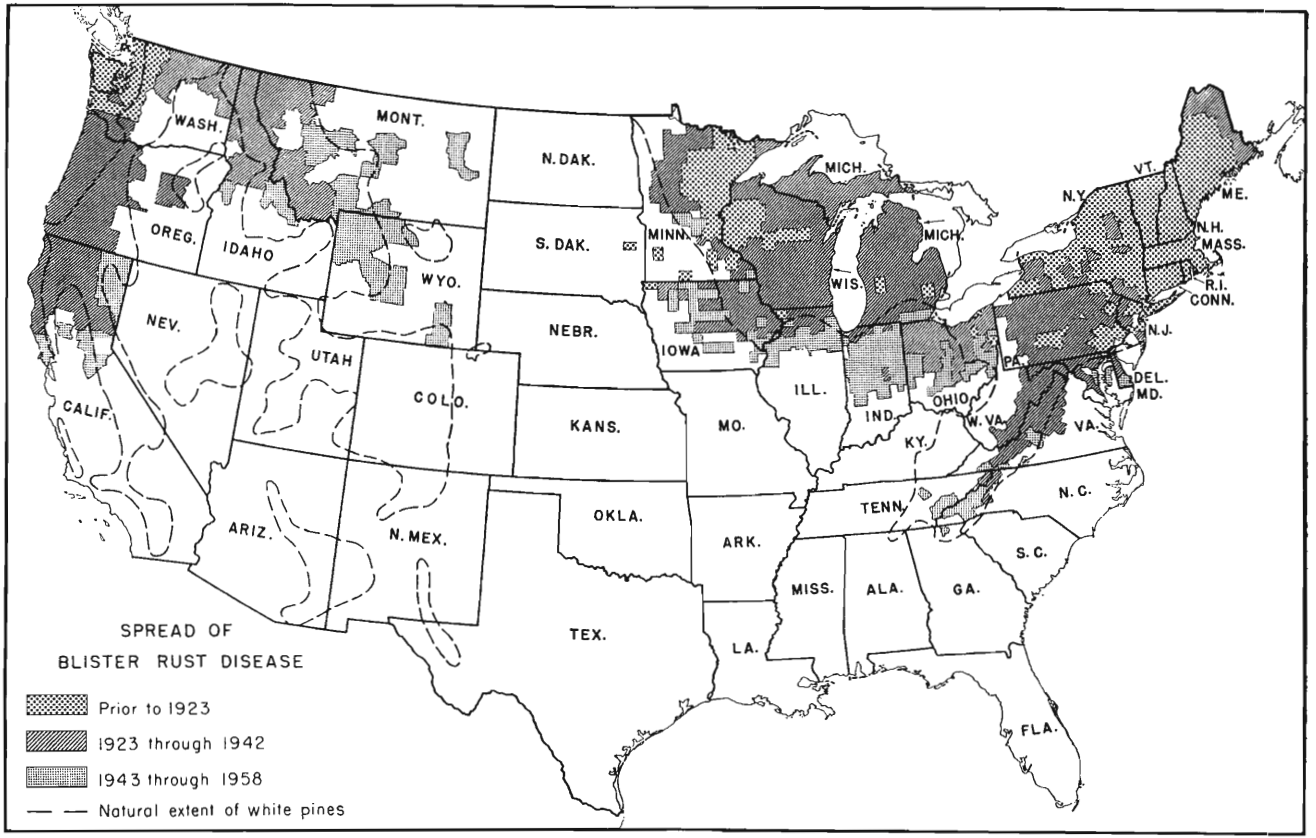

Figure 1.—How white pine blister rust has spread through the United States.

then no longer practical to seek out and destroy the infected trees; so since 1915 efforts to control the disease have been through destruction of ribes plants.

In 1921, the disease was found on western white pine near Vancouver, British Columbia, and in northwestern Washington. These outbreaks were traced to infected pine nursery stock shipped to Vancouver from France in 1910.

Distribution

White pine blister rust has spread relentlessly over the years. In the East, it is now present throughout all except the southern fringe of the range of eastern white pine—from Maine to North Carolina to Minnesota (fig. 1). In the West, the disease seemed to fan out slowly at first, but in the early 1920's the rate of spread increased and by 1930 the disease was as far south as the sugar pine stands in northwestern California and as far east as the white pine stands of western Montana. Now the disease is found half way down the length of California and as far east as western Wyoming.

Hosts

White pine blister rust has been found in western European plantations on nearly all the white pine species of the world. Eastern white, western white, sugar, whitebark, and limber pines have become infected in their natural habitat in the United States. No infection has been found in native stands of foxtail pine (*P. balfouriana* Murr.) and the disease has not yet reached the range of bristlecone (*P. aristata* Engelm.) and Mexican white pines (*P. ayacahuite* Engelm.). These pines have been infected in controlled inoculation tests.

Ribes species vary widely in their susceptibility to the rust and also in their capacity to produce pine-infecting spores. About half of the 80 species of ribes native to the United States grow within the white pine range. Some of these species, such as *Ribes bracteosum*, are extremely susceptible; others, such as *R. cereum*, are highly resistant. Ribes populations vary from several thousand per acre to occasional bushes scattered over large areas.

Life Cycle

White pine blister rust completes two of its spore stages in the bark of pines and the other three stages on leaves of ribes (fig. 2). On ribes the rust is a relatively harmless annual: on pines it is a damaging or killing perennial.

The disease cannot spread from pine to pine: it must be transmitted to pine by spores (called sporidia) produced in the final stage of the rust on ribes leaves. On ribes, the first infections in early spring are from aeciospores released from the cankers on pine. Later the rust spreads from ribes to ribes. Although blister rust may spread hundreds of miles from pines to ribes, its spread from ribes back to pines is usually not more than a few hundred feet. Under highly favorable conditions, however, the rust may spread a mile or more from ribes to pine.

Conditions are most favorable for germination of blister rust spores when temperatures remain in the range of 50° to 60° F. and relative humidity holds at 97 to 100 percent for a period of about 48 hours. Each type of spore requires about the same temperature and moisture conditions for germination.

Symptoms on Pines

On pine, the disease first appears (4 to 10 weeks after infection) as small discolored spots on the needles. Twelve to 18 months

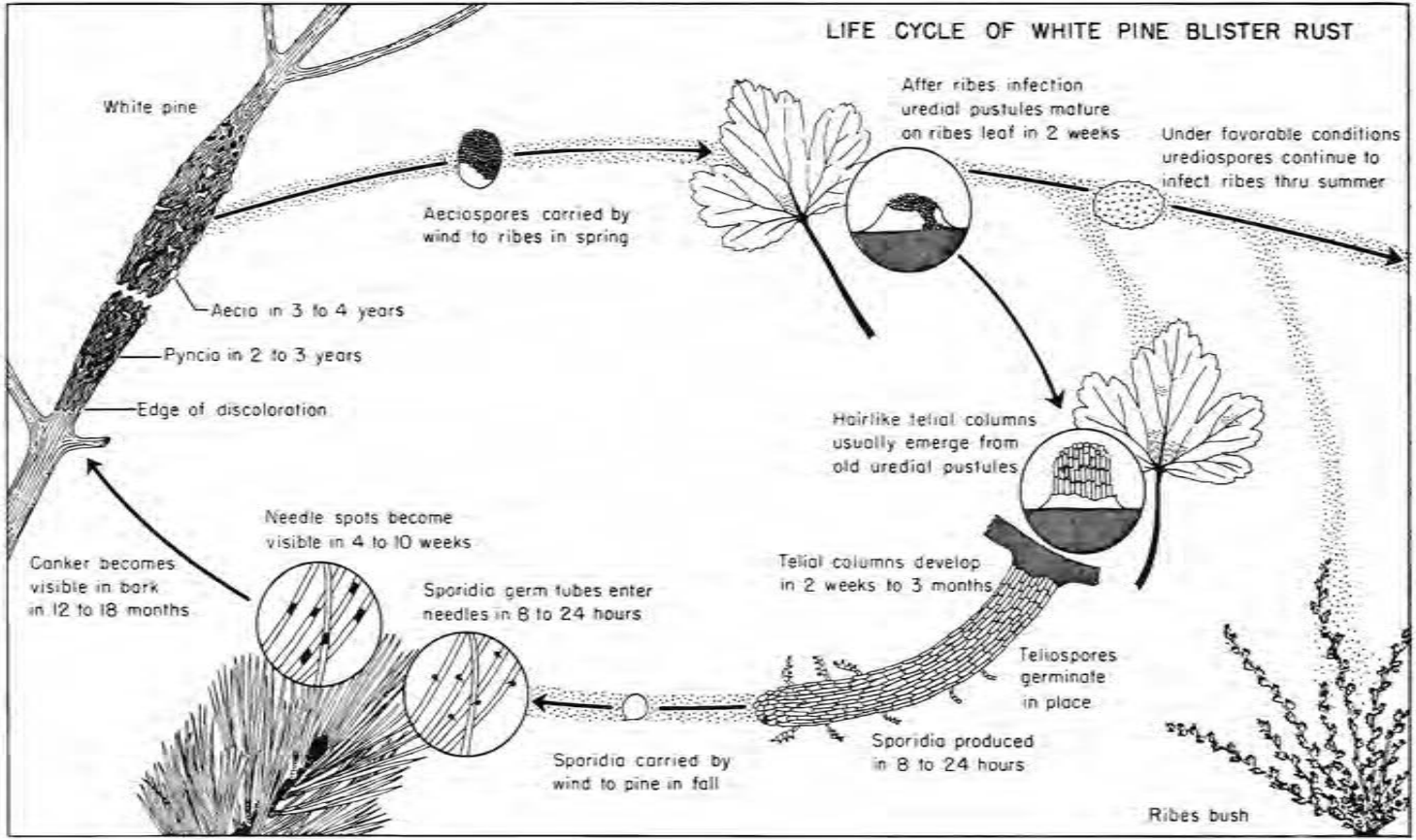

Figure 2.—Life cycle of white pine blister rust.

after infection, a yellowish to orange discoloration of the bark appears at the base of the infected needle bundle. As the fungus grows within the bark, the discoloration spreads and the bark becomes swollen. About August of the third season after infection (22 to 24 months after infection) honey-colored to brownish drops of liquid, called pycnial drops, exude from the branch swelling. The next spring white blisters containing orange-colored spores, the ribes-infecting aeciospores, push through the outer bark at the same places where the pycnial drops appeared the previous summer. The pycnial-aecial sequence is repeated each year as the perennial fungus advances through the bark.

After the blisters break and the aeciospores have been shed, the bark in the area of the blister begins to darken in color and roughen in texture. Continued growth of the fungus both up and down the branch or trunk produces a spindle-shaped canker. As the fungus invades living tissues it kills them and eventually the affected branch or trunk is girdled and dies. Trunk cankers on pole-size or larger trees may be several feet long before the tree is girdled and the top killed (fig. 3).

On branches killed by blister rust, the needles turn a reddish copper color. They remain attached throughout the summer in which they die and often during the following season. These reddish "flags" in the crown of a white pine tree often indicate that one or more cankers are present in the tree. Cankers and flagged limbs occur more commonly in the lower part of the crown, but where conditions are highly favorable for rust development, all parts of the crown may be infected. Numerous cankers may defoliate a tree by killing all the needle-bearing twigs. Under such conditions even mature trees may be killed by limb and twig cankers rather than by trunk cankers.

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Figure 3.—Large blister rust canker on a western white pine, showing blisters, which contain ribes-infecting aeciospores.

Symptoms on Ribes

On ribes, the rust first appears in the spring on the under side of the leaf as small light-colored dots. These are the beginnings of the summer spores. Within a few days the dots develop into yellowish to light orange spore pustules known as the uredial stage (fig. 4). Generally only one or a few pustules appear on a leaf at the time of initial infection. As the summer spores scatter and germinate, the rust intensifies; more leaf area is covered and more leaves on the same and other ribes plants are infected.

The fall spore columns (telia) appear in late summer and early fall. They are short brownish hair-

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Figure 4.—Ribes leaf infected with blister rust. This is the summer or uredial stage.

like structures made up of many teliospores that push through the old summer spore pustules. On some ribes species these telial columns are so numerous that they form a brownish mat on the under side of the leaf (fig. 5). The function of teliospores is to produce still another spore form called sporidia. Each teliospore is capable of producing four sporidia. The sporidia are the spores that spread to and infect pine. A cool moist period of 8 to 24 hours is needed to germinate the telia and produce sporidia. Many of the thinner leafed gooseberries that grow on dry sites drop their diseased leaves prematurely when heavily infected.

Control

White pine blister rust can be controlled. Since the fungus cannot spread from pine to pine but requires an alternation of host plants to complete its life cycle, control is obtained by breaking the cycle at its weakest point. This point occurs when the ribes host releases the pine-infecting spores (sporidia), which lose their viability soon after being cast into the air.

Effective control is obtained by destroying ribes bushes growing in white pine stands and in a protective zone around them. The required width of the protective strip may vary from a few feet to a mile or more (usually 500 to 1,000 feet), depending on climatic conditions, elevation, latitude, and the species of ribes and pines.

The level to which the ribes population must be reduced to give satisfactory protection also varies. On some areas where the rust has been present on pine in small pockets for a number of years with no apparent intensification, little if any reduction in ribes population is required. On most control areas the ribes population must be reduced to a low level. Where climatic conditions are most favorable for rust activity even one small ribes bush per acre is enough to cause serious damage to pines.

The first step in planning a control job is to appraise the economic or aesthetic value of the white pine and determine the abundance, distribution, and species of ribes. In commercial timber areas only forest lands that support sufficient white pines to justify the cost of control are selected for protection. Control units vary in size from a few acres to several thousand acres.

Two direct methods of destroying ribes are used in blister rust control work: (1) Digging or pulling the bushes by hand, or (2) spraying with herbicidal chemicals. Most of the control work is done by digging or pulling, usually with tools developed especially for this purpose. For killing ribs that are too difficult or costly to dig, effective chemicals and equipment have been developed. 2,4-D and 2,4,5-T are generally the cheapest and most effective. Broadcast and selective

spraying of foliage and stems, basal stem application, and cut-surface treatment of individual root-crowns are the principal chemical methods now in large-scale use.

Silvicultural treatments, including judicious use of fire, can sometimes be used to reduce and help maintain ribes populations at low levels in white pine stands.

Where the rust is not aggressive, its spread can be slowed by removing the few pine cankers and eradicating the ribes growing near infected pines. Under these conditions this practice shows promise of effecting an adequate measure of control. Pruning selected crop trees in young pine stands, either planted or natural, is also a good supplemental measure in many control areas. This procedure not only saves crop trees by removing damaging cankers but improves the quality of lumber produced. The chances of future infection are also reduced by eliminating the most susceptible part of the tree's crown.

Still another approach to control, and of necessity a long-term one, is through selecting and breeding pines resistant to the rust. Substantial progress has been made during the past 10 years in developing resistant eastern and western white pines. Progress has been slower with sugar pines because the rust has not been present in most sugar pine stands long enough to differentiate resistant trees, especially trees of cone-bearing age that can be used to propagate selected breeding stock.

There are now 23 million acres in the white pine blister rust control area. However, this area will vary as logging and fire reduce the white pine acreage and as natural restocking and planting increase it. Included in the present program are 10½ million acres of the most valuable white pine bearing lands in the Nation and 12½ million acres in surrounding protective zones. Of this total acreage, 18 million are on maintenance (protected) and another 4 million have received partial control. In accomplishing this, 1⅓ billion ribes bushes have been destroyed. There are still 1 million acres of control area not yet receiving any protection.

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Figure 5.—Portion of infected ribes leaf showing the fall or telial stage.

The Forest Service of the U.S. Department of Agriculture is responsible for much of the research on the disease and for overall leadership, coordination, and technical direction of control programs. This work is carried out in close cooperation with other Federal agencies, States, and private landowners. Participating in the program are 30 States, many counties, townships, lumber companies, timber-protection associations, and individuals. Control on State and private lands is financed jointly with Federal and State funds, supplemented by county, township, private, and local contributions and services.

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