History of the Origin and Dispersal of White Pine Blister Rust

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SUMMARY. The center of diversity for white pine blister rust (WPBR) (*Cronartium ribicola* J.C. Fischer) most likely stretches from central Siberia east of the Ural Mountains to Asia, possibly bounded by the Himalayas to the south. The alternate hosts for WPBR, Asian five-needled pines (*Pinus* L.) and *Ribes* L. native to that region have developed WPBR resistance. Because the dispersal of *C. ribicola* to Europe and North America occurred within the last several hundred years, the North American five-needled white pines, *Pinus* subsections, *Strobus* and *Parya*, had no previous selection pressure to develop resistance. Establishment of WPBR in North America resulted when plants were transported both ways across the Atlantic Ocean. In 1705, Lord Weymouth had white pine (*P. strobus* L.), also called weymouth pine in Europe, seed and seedlings brought to England. These trees were planted throughout eastern Europe. In the mid-1800s, WPBR outbreaks were reported in *Ribes* and then in white pines in eastern Europe. The pathogen may have been brought to Europe on an infected pine from Russia. In the late 1800s American nurserymen, unaware of the European rust incidence, imported many infected white pine seedlings from France and Germany for reforestation efforts. By 1914, rust-infected white pine nursery stock was imported into Connecticut, Indiana, Massachusetts, Minnesota, New Hampshire, Ohio, Pennsylvania, Vermont, and Wisconsin, and in the Canadian provinces of Ontario, Quebec, and British Columbia. The range of WPBR is established in eastern North America and the Pacific Northwest. New infection sites in Nevada, South Dakota, New Mexico and Colorado have been observed during the 1990s.

White pine blister rust causes cankers on five-needled white pines and can kill weakened, infected trees after several years. The currants and gooseberries (*Ribes* L.) are alternate hosts for this disease. Orange rust uredia develop on the under surface of currant or gooseberry leaves during the summer. Severe infection in these shrubs causes defoliation not death. During the past century, forestry practices in the United States have attempted to eradicate *Ribes* but this has proved unsuccessful in controlling the rust. The concept of eradication and state regulations have prevented the development of a *Ribes* industry in the United States during the past century. A brief historical summary of the origin and dispersal of the rust within the United States are presented here as a basis for further discussion concerning *Ribes*, pines, and white pine blister rust.

Historical timeline

Recent evidence indicates that *Cronartium ribicola* may not be as ancient as originally believed (Millar and Kinloch, 1991) but more likely evolved during the Miocene epoch (Vogler and Bruns, 1998). The center of origin of *C. ribicola* is probably in central Eurasia (Leppik, 1967; Spaulding, 1929), east of the Ural Mountains, through what is now central Siberia, reaching to the Pacific coast of Asia in the east and southwards to the Himalayas. Survival of Asian five-needled pines required development of WPBR resistance.

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The dispersal of *C. ribicola* to Europe and North America occurred within the last 200 years, (Leppik, 1970; Spaulding, 1929) so the North American subsections, *Strobis* and *Parya*, have not had previous selection pressure to develop resistance to *C. ribicola*.

Explorers from the 15th to the 17th centuries realized the value of transporting plants between the continents, but sometimes diseases were imported as well. WPBR establishment in North America resulted from the shipment of white pines eastward across the Atlantic Ocean and then infected white pines returning from Europe.

The process of introduction of WPBR into North America began indirectly in 1705 when Lord Weymouth had white pine seedlings brought to England (Maloy, 1997; Stewart, 1906). These pines were planted in many locations throughout Eastern Europe (Spaulding, 1929) and were highly prized as ship masts because of their tall, straight growth habit (Maloy, 1997).

Nomenclature of *Cronartium*

Fries (1815) described the genus *Cronartium*; Authur (1933) corrected the taxonomic authority for *C. ribicola* Fischer based on an infected *Ribes* herbarium specimen collected by Lasch in the Baltic region in 1842; H. A. Dietrich (1856) first put the binomial *C. ribicola* into print, but he neglected to publish a description of the rust. J. C. Fischer, a retired schoolteacher and naturalist from northern Germany is generally acknowledged as the species author (Maloy, 1997).

Epiphytotic events in pines

In 1856, the rust was first reported from western Russia (Stewart, 1906). Epiphytotic outbreaks of this disease were not known in Europe or Asia prior to the introduction of eastern white pine, i.e., weymouth pine, from America to Europe (Leppik, 1970). This pathogen may have been inadvertently imported from Russia to Eastern Europe on a stone pine (Stewart, 1906). Although Stewart (1906) referred to this pine as *P. cembra* L., the siberian stone pine is now referred to as *P. sibirica* Du Tor. The pathogen became distributed through-

out western Europe in young infected trees of *P. strobus* (Spaulding, 1929). In 1865, Dietrich observed the rust on pines in Estonia (Leppik, 1970). In 1887, Klebahn reported an outbreak of the rust among white pines in the vicinity of Bremen, Germany, and named the pathogen *Peridermium strobi* (Leppik, 1970). He continued experimenting and after subsequent cross-species inoculations, realized that *C. ribicola* and *P. strobi* were different stages of a single species.

American introduction

By the mid-1800s the demand for eastern white pine lumber and the improvement of logging equipment accelerated the regional depletion of the forests (Maloy, 1997). A premium was placed on nursery stock, however the low market value of pine seedlings for reforestation discouraged American production. German French and Dutch nurseries were producing planting stock at prices substantially lower than those in America. Tariffs were removed and a large number of pine seedlings were then imported from Europe (Maloy, 1997), particularly from France and Germany. Because rust-infected pines did not show symptoms for several years, the diseased seedlings were unknowingly imported.

American establishment

Near the turn of the 20th century, North American plant pathologists became concerned about potential importation of WPBR from Europe. Americans and Canadians did not wish to lose the North American white pines to an exotic disease. In the mid-1890s, WPBR was present in only localized areas of North America (Spaulding, 1929). The significance of the disease was realized in 1906 when the *Ribes* plantation at the New York Agricultural Experiment Station at Geneva, NY, became infected with WPBR. The orange-colored powder, i.e., uredia with uredinal spores, was observed on the under surface of the leaves of 48 clones, including black currants, *R. nigrum* L., red currants, *R. rubrum* L. and golden currant, *R. aureum* Pursh (Stewart, 1906). Though these *Ribes* were indicators of the rust's presence in North America rather than its carrier from Europe, the Geneva scientists destroyed every *Ribes* plant on the Experiment Station grounds in a futile attempt to eradicate the rust.

Unfortunately, many rust-infected pine seedlings continued to be planted throughout northeastern North America. By 1911, nursery inspectors discovered imported rust-infected white pine nursery stock in New Hampshire, Vermont, Massachusetts, Connecticut, Pennsylvania, Indiana, and Ohio, and in the Provinces of Ontario and Quebec (Benedict, 1981). U.S. Forest Service pathologists recorded that several million white pine seedlings were shipped in 1909 from Halstenbeck, Germany, where WPBR was known to occur, to more than 226 locations in America (Benedict, 1981). Many other rust-infected white pines were imported from France.

By 1915, native New York white pine stands became infected. WPBR infections were found in native white pines in Polk County Wisconsin in 1913, in Minnesota in 1914, Ontario in 1915, and in Michigan in 1917 (Benedict, 1981; McCobbin, 1916). By the early 1920s, WPBR was clearly established in the northeastern United States and forest pathologists began to focus on control measures.

Disease in the west

In 1910, a shipment of eastern white pine seedlings from France was received in Vancouver, British Columbia, Canada. The rust, undetected in the original shipment, spread to native western white pines and cultivated black currants in the Vancouver, BC, vicinity and was discovered in 1921. Over the next 20 years the rust spread eastward to Idaho and southward through Washington and Oregon to California and became the source of WPBR throughout the Pacific northwestern North America (Benedict, 1981).

By 1940, WPBR was observed spreading eastward in Montana and by 1960, reaching Laramie, WY. Although initial thoughts suggested that the rust would stop at Placerville, Calif., it was observed in the southern Sierra Nevada range in the 1960s (Kliejunas, 1982). Observations in the 1990s indicated that WPBR had reached the mountains west of Reno, Nev., and the Sacramento Mountains of New Mexico sometime in the late 1970s (Hawksworth, 1990). Additional locations with WPBR were discovered on Gallineus Peak of the Capitan Mountains of New Mexico and in the Black Hills of South Dakota in 1992 on limber pine, (*Pinus flexilis* E. James),

and wax currant (*Ribes cereum* Douglas) (Lundquist et al., 1992). WPBR was first reported in Colorado in 1998 (W.R. Jacobi and D. Johnson, personal communication).

The rust continues to expand its distribution throughout the western states. Foresters and pathologists are concerned about potential spread into Mexico. They are now closely monitoring for rust incidence in pines and *Ribes* in the high elevations throughout the Great Basin and the southwestern United States.

This disease can cause white pine tree mortality in fragile ecosystems. An integrated approach to control, including the planting of genetically resistant pines, or resistant or immune currants and gooseberries and the application of cultural management techniques such as maintaining planting distances between pines and *Ribes*, limbing-up of cultivated pine trees, oil spray of leaves of cultivated *Ribes*, may assist in dealing with this exotic disease that is now resident in North America.

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