White Pine Blister Rust

Cronartium ribicola

Infection Incidence for Selected Areas of New Hampshire

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Acknowledgments

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Finally, we would like to thank all those foresters and technicians from the early days who quickly realized the threat blister rust posed to New Hampshire's early successional forest. Without their knowledge and dedication, the Forest Insect and Disease Section would not be in a position today to work on current forest health issues in New Hampshire.

About the New Hampshire Division of Forests and Lands

The Division of Forests and Lands is a part of the Department of Resources and Economic Development. The Division's mission is to protect and promote the values provided by trees and forests. To accomplish this goal the division manages state forest resources, provides information and education, and provides leadership in the protection of New Hampshire forests.

Within the Division of Forests and Lands, the Forest Protection Bureau is responsible for providing statewide leadership in forest protection. To meet this goal the bureau enforces forest harvesting laws, provides state-wide monitoring and investigation of abiotic and biotic forest damaging agents, and provides training and assistance to control wildland fires.

Within the Forest Protection Bureau, The Forest Insect and Disease Section is responsible for providing current data on populations, trends and effects of forest insects, diseases, weather events, or abiotic stressors. The insect and disease section also provides investigation, technical assistance, and training with regard to current forest health indicators.

Introduction

At the turn of the 20th century, a little known fungal disease called white pine blister rust, *Cronartium ribicola*, (WPBR) spread from Russia westward into Europe. At the same time in the eastern United States, large quantities of white pine seedling were needed for massive reforestation efforts.

Herbicide spraying from a backpack pump was a popular means of ribes eradication.

New England foresters turned to forest nurseries in France and Germany to fill this demand. Because they didn't know about WPBR, some shipments into New York were infected with what would become the most severe disease of white pine in North America. In 1909 the first outbreak was found in Geneva, New York. By 1922, WPBR surveys in New Hampshire showed areas with as much as 50% of the pine stems infected (USDA, 1953).

After pulling the ribes plants out of the ground, hanging them in a tree dries and kills the roots.

It was thought that since this disease requires an alternate host of *Ribes spp.* (gooseberries and currants), eradication of the alternate host would prevent further spread of the deadly WPBR. In 1917, New Hampshire prohibited the sale or planting of any ribes species and started many aggressive ribes eradication programs. By 1953 an estimated 7 billion board feet of lumber production was lost due to this disease (USDA, 1953).

If those trees had survived, they would be mature trees today. Based on current stumpage prices, the value to the landowner would be $1.05 billion. The value to the state as a whole through value added manufacturing and recreation would be ten times that amount. Ribes eradication programs dominated the forest pest arena from 1917 until the late 1970's. Ribes plants were destroyed throughout the range of eastern white pine with the use of herbicides and plant pulling techniques.

Starting in the late 1970's, serious questions arose about the effectiveness of eradication programs and enforcement of the ribes quarantine. At the same time the white pine resource in New Hampshire was maturing and the prime ribes sites overtopped with hardwood forests. Today there are no eradication programs, the quarantine goes largely unenforced and until this survey, we had little information on the current status of blister rust infection statewide.

Mechanical pulling of ribes plants was also an eradication method.

Disease Biology

The white pine blister rust disease (WPBR) is a classic example of a tree rust fungi. "Blister" describes the effect on pine bark after infection. "Rust" describes the physical characteristics of the fruiting bodies on host tree bark or leaves. In the case of WPBR, the damage causing fungus is *Cronartium ribicola.*

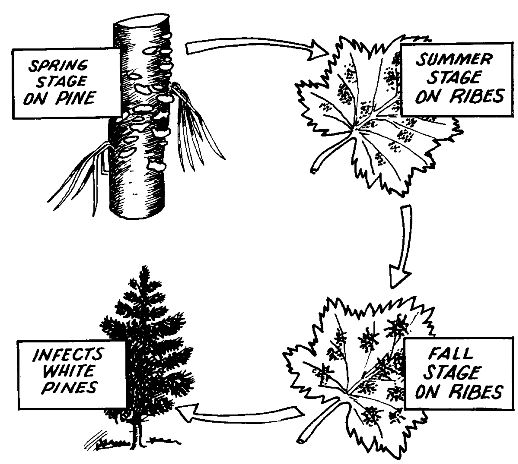
Branch with berries from a currant bush

Like most other rust diseases, WPBR requires two completely different host species to complete its life cycle. In this case the two hosts are eastern white pine and almost any of the native ribes species (approximately 70 in North America).

The cycle begins with disease spores which attach themselves to needles of eastern white pine in the late summer and early fall. These spores penetrate through stomata on the pine needles and then start colonizing and expanding down into the twig. Within one to four years, the twig is infected and the disease breaks out through the thin bark causing blisters and bark cracking.

Once the cambium is broken and killed, the tree response is usually pitching from the damaged area. Once the disease has broken out through the bark, it travels at about two inches per year toward the main stem of the tree. At this same time, a different type of spore is produced on the surface of the white pine branch and is wind-blown in search of the alternate host. If the spores find a ribes plant they attach and infect by spring and early summer. A series of spore development stages take place on the surface of the ribes leaf and by late summer, there are spores capable of infecting white pine. None of the different spore stages generated on the pine tree are capable of infecting other pine trees. This isn't true of spores found on ribes plants. These spores do travel to other ribes and colonize.

How Blister Rust Spreads



Simplified life cycle showing the importance of an alternate host

Symptoms of Blister Rust on White Pine

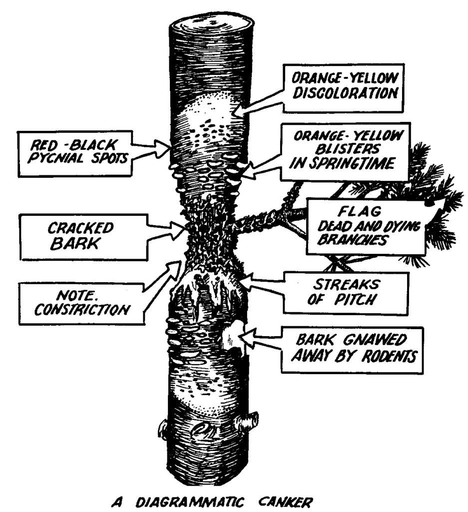
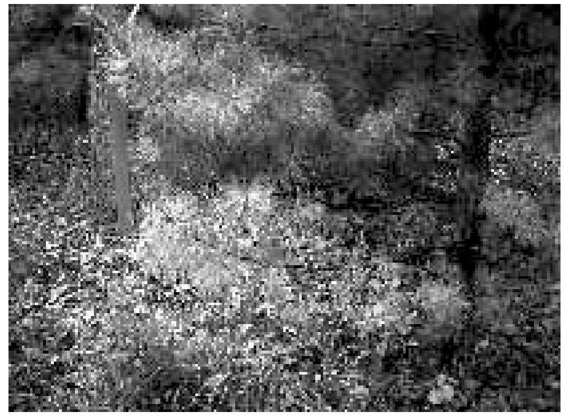


Diagram denoting common symptoms of blister rust on a white pine

Field Identification



The first sign of infection is the death of single branches which turn yellow. This symptom is called "flagging."

The first sign a pine is infected with WPBR is yellowing of a group of needles. This yellowing will spread to all of the needles on the branch. This first stage is called "flagging". Once the disease reaches the main branch, WPBR manifests itself in much the way poison ivy does on humans. Pockets of yellow, slimy spores grow under the thin bark until the bark ruptures and the spores ooze out. After a period of several years the disease finally reaches the main stem of the tree.

At this point, the cambium is killed around the branch collar and cambium mortality progresses around the tree until the tree completely dies. The larger and more vigorous trees tend to resist the disease for many years. This creates a canker, a flattened dead area along the bole, with a dead branch stub in the middle. Moderate pitching is usually associated with the outer edge of the canker.

Wildlife such as porcupines are attracted to this disease-sweetened area of the bark and cause additional wounding. Blister rust can be mis-identified in the field because heavy pitching has long been associated with this disease. Blister rust cankers, in many cases, pitch very little in comparison with mechanical wounds or pine canker (*Caliciopsis pinea*) infections. If the pitching is internodal, thus not associated with a branch, it isn't a sign of blister rust. To make a positive field identification, it is important to find evidence of the branch that the disease infected.

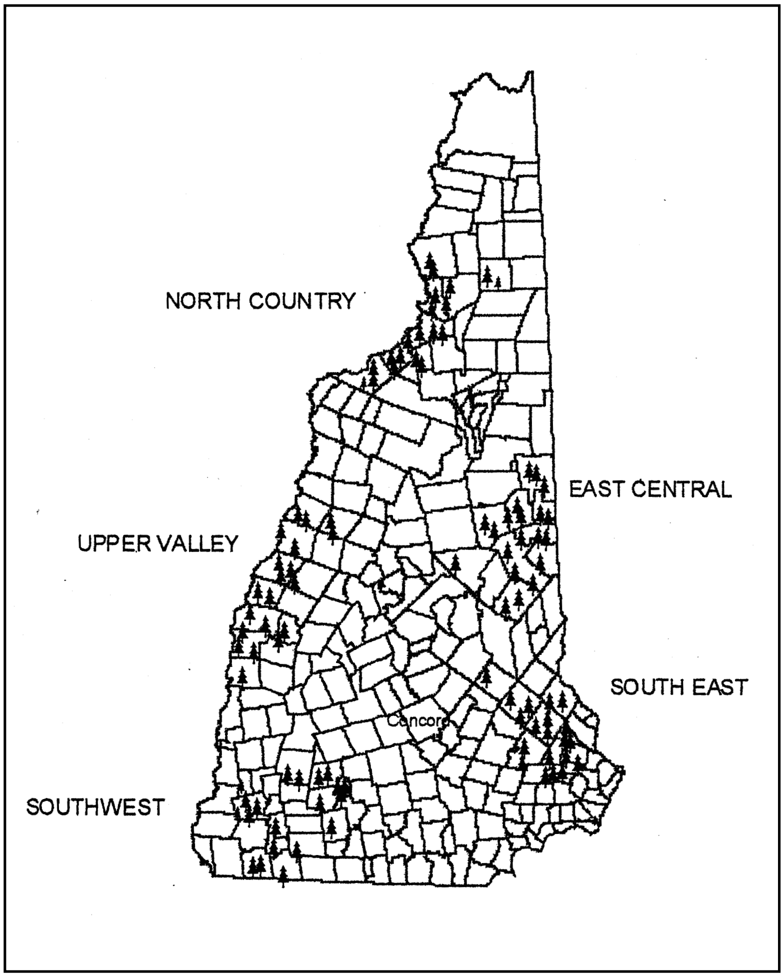
Classic example of a young pine sapling with a severe basal infection. Note the branch the disease entered on and the infectious spores in a target shape on the stem.

This blister rust canker has recently been chewed by a porcupine. Many small animals find the newly infected bark irresistible.

This gentleman from the 1930's felt it necessary to climb this white pine tree to point out the blister rust infection.

Survey Methods

Five separate regions of New Hampshire were surveyed in 1998 for the presence of white pine blister rust. Each separate survey region encompasses eight to 12 towns for a total of 50 towns surveyed. Survey regions consisted of the north country, upper valley, southwest, southeast, and east central zones of the state. In each of these regions, approximately 20 sites were established and at each site, five subplots of 10 white pine trees were systematically sampled.



This method provided approximately 1000 white pine trees in each zone for analysis. Approximately equal amounts of seedling/saplings, pole timber, small sawlog, and large sawlog size trees were sampled within each zone. Sites were located randomly by driving roads transecting through the zone. To qualify as an appropriate survey site, the forest had to be more than 90% stocked with eastern white pine, larger than two acres, and show no signs of timber harvesting since the stand was established.

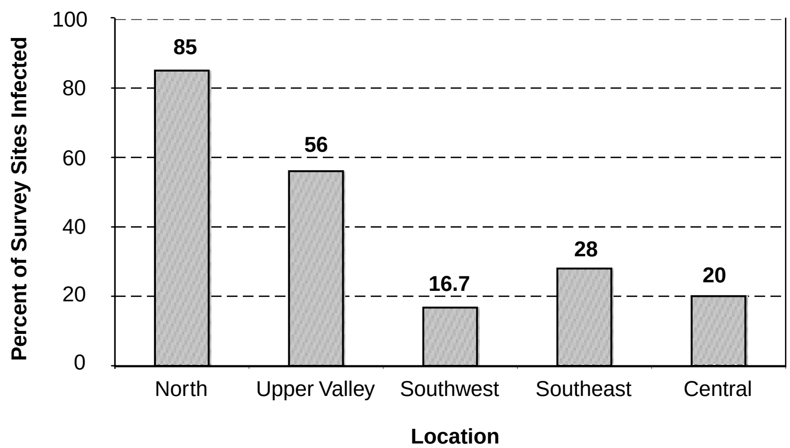
Results

A total of 5195 white pine stems were examined for WPBR. Trees were located on 104 different sites grouped in 5 different regions of New Hampshire. One hundred twenty three (2.4%) of the 5195 trees examined were identified as having at least one bole or branch canker of white pine blister rust.

The frequency of WPBR in each region was determined by calculating the percent of all sites visited with at least one infection. Figure 1 shows that the north region had the highest percentage of plots infected with WPBR. The southwest region of New Hampshire had the lowest percentage of diseased plots.

Figure 1–Frequency of Infection

Percent of Survey Sites Infected by Region Surveyed



The north region of New Hampshire, extending from Littleton to Lancaster, had the highest incidence of infection (Table 1). 7.2% of the 1000 trees inspected in that zone had at least one WPBR canker. The southwest region of New Hampshire had the smallest percentage of infection. Just 0.3% of the surveyed stems were infected. The size class with the highest incidence of infection was the large sawlogs. Trees over 14 inches at diameter at breast height (dbh) had a statewide infection incidence of 3.2%. However, there is no significant difference between any of the classes.

Table 1–Incidence of Infection

Percent Infection by Size Class for Each Region Surveyed

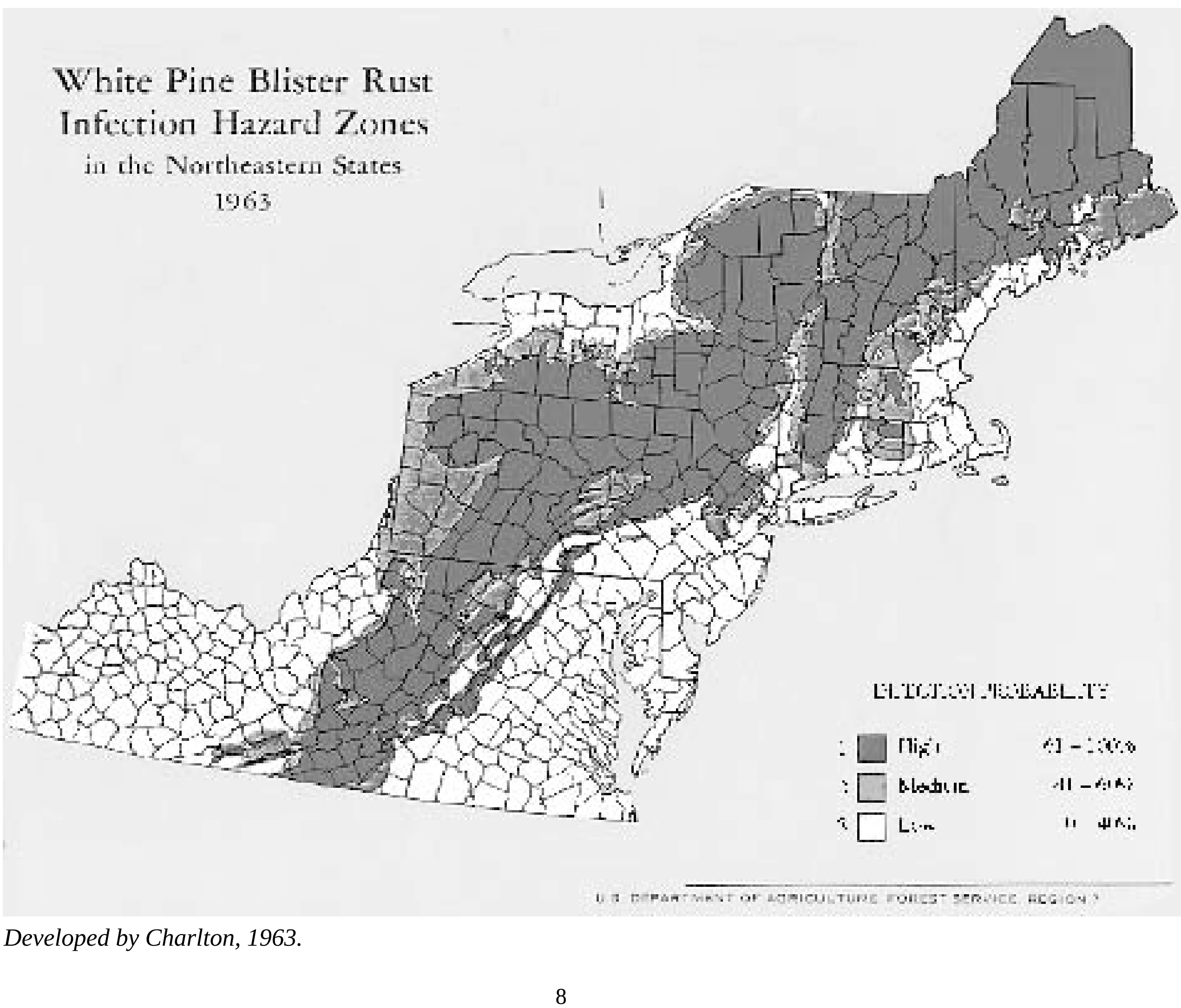
Region	*Seed/Sapling*	*Pole size*	*Small sawtimber*	*Larger sawtimber*	*All size classes*
North	6.2	6.6	10.2	9.4	7.2
Upper Valley	2.7	2.6	2.4	3.6	2.7
Southwest	0.8	0.4	0.0	0.0	0.3
Southeast	2.3	0.6	0.8	1.8	1.2
Central	0.3	0.9	0.5	0.4	0.6
Total	**2.2%**	**2.4%**	**2.4%**	**3.2%**	**2.4%**

Discussion

This study's main objective was to determine how the incidence of blister rust has changed since the mid-1900's. To get comparable infection level data from past decades, we searched for state-wide surveys done by foresters or researchers. Surprisingly, we found no previous statewide inventory data on the amount of infection. However, we did find anecdotal information from old newspaper articles and local survey reports such as "*The Hurlin Plantation, A Case Study,*" (S.H. Boomer, L.E. Newman 1950) and regional reports like *White Pine Blister Rust Control, The Annual Report* (USDA Bureau of Entomology and Plant Quarantine, 1953).

Within these reports, the incidence of infection on live trees ranged from 20% to 80%. Based on our survey results and the data from early to mid 20th century reports we have far less blister rust incidence of infection than we had in the past. However, the results of this survey suggest the disease is still well distributed in the northern regions of the state, yet less severe within each timber stand. Live blister rust cankers in the north country occurred on 85% of all sites, while in the southwest they occurred on just 16.7% of the surveyed sites.

These results are consistent with a 1960 study done by John Charlton of the USDA Forest Service (Charlton 1963). Charlton published the results of a study on the different climatic zones of the northeast and the probability of infection from WPBR in each zone. He divided the northeast United States into high, moderate and low hazard zones based on mean nocturnal summer temperatures and regional air saturation levels.



Developed by Charlton, 1963.

WPBR spore production and longevity depends on cool temperatures and high amounts of moisture, so the cooler and moister regions of New Hampshire received the highest hazard rating. When comparing our results by region to these hazard zones, we discovered the north region of the state with the coolest nocturnal temperatures and highest amount of precipitation had the highest amount of infected white pine trees. The second highest amount of blister rust infection occurred in the upper valley region and this area is also located in the high hazard zone. It is interesting that our two least infected regions both occurred in the moderate hazard zone (southwest and central NH), while the moderately infected region fell in the low hazard rating zone (southeast).

While blister rust infection is still common in many regions of New Hampshire, the severity of the incidence of infection has declined dramatically. The reason for this decline in incidence of infection is due to a number of contributing factors. One factor is described by statewide forest inventory data (Cullen and Leak 1988).

Cullen and Leak report 78% of the white pine resource in New Hampshire is in the sawlog size class. In 1973 it was 57% and in the years prior to 1973 the percentage of large pine was even smaller. This data is significant when combined with the fact that white pine trees with live branches within 10 feet of the ground are most susceptible to infection. These facts combined would suggest the majority of pine has grown out of the susceptible age class, so the infection rate has dropped.

This mature forest condition can't be the only factor contributing to reduced infection statewide. If it were, high amounts of blister rust among the small size classes would be evident. We believe an important factor contributing to the low incidence of infection in small size classes is the reduced number of ribes bushes throughout New Hampshire. It's theorized that if an alternate host is less abundant then the chance of infection will be reduced.

Cullen and Leak, in 1988, describe New Hampshire forests as "...highly skewed towards fully and overstocked stands. Herbaceous ground cover conditions and shrub layers, many times available under poorly stocked and nonstocked stands, are unlikely to be available in any noticeable way." It appears that the conversion of old agriculture land to mature hardwood stands is almost complete in New Hampshire and the amount of preferred habitat for the alternate host has been severely reduced. To support this further, an analysis of the preliminary data from the 1998 statewide forest inventory (done by the USDA Forest Service in 1996 and 1997) shows that just 10 plots of the 1000 statewide had ribes plants on them.

Six of the 10 infested plots were in the northern two counties where the highest incidence of WPBR occurred. The other four were distributed equally throughout the larger southern portion of New Hampshire. It's worth noting that five of the six ribes infested plots found in the north had fir, spruce, elm, or black ash in the overstory. These species are generally associated with wet sites. This data further supports what we already know about habitat requirements for ribes.

A third and related factor that could be contributing to reduced blister rust infections is the effectiveness of ribes eradication programs. Ribes pulling and chemical spraying started in the 1920's. and continued until the early 1970's. As many as 3000 acres per year in New Hampshire were "ribes controlled". This large effort over such a long period of time surely reduced the numbers of ribes plants in the population.

Results of this survey suggest there is no significant difference in infection incidence between size classes. To better understand this, it is important to note that incidence of infection is equal to the overall amount of live infection at any one time in a forest. You must add new infections and subtract mortality to achieve incidence of infection. White pine blister rust invades through live branches close to the ground, so you would expect the smaller size classes to have higher rates of infection and higher rates of mortality, but not necessarily higher incidence of infection. If the mortality rate is close to infection rates then the incidence of infection is low.

On the sites we visited, we believe the mortality rates, though very low, are offsetting the infection rate in the smaller size classes. Conversely the large, thick-barked, well-established pines probably survive with the canker much longer than suppressed, densely stocked sapling stands, giving us higher than expected incidence of infection figures for those large trees.

Outlook For the Future

It's fair to suggest that if prime habitats for ribes continues to decline, no new ribes are introduced, and most of New Hampshire's pine resource continues to grow out of the most susceptible size classes, the statewide incidence of white blister rust will remain at current low levels. However, there will be rare occasions in the north where pockets of pine regeneration receive heavy amounts of infection.

It's generally recommended that foresters in the high hazard zones regenerate white pine under an existing overstory. The overstory helps prevent moisture build-up on the needles which is vital to the formation of blister rust. The Minnesota Department of Natural Resources suggests the worst practice is to manage young pine in small openings at the base of slopes or in low areas for the very same reason. If the forester, in high hazard zones, can afford to enter the stand shortly after the final overstory removal of the previous stand to thin out any infected poles, and prune as many as 200 of the best stems, the stand should be maintained as pine.

If low stocking levels, poor site index, or an exceptional infection rate persists after thinning, the stand may need to be converted to a more appropriate forest type. In general, with proper white pine silviculture and an understanding that some mortality in the dense seedling / sapling stands contributes to improving the health of residual growing stock, white pine blister rust should not be a limiting factor for foresters interested in pine management throughout New Hampshire.

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