WHITE PINE BLISTER RUST

State Forester Forum

Introduction

Cronartium ribicola, the fungus that causes white pine blister rust (WPBR), was introduced into western North America from Europe and eastern North America in the early 1900s on shipments of eastern white pine seedlings (Hunt 2009). The disease spread rapidly due to its aerially-dispersed spores and reached northern Idaho in the early 1920s. It is now distributed throughout the range of the five-needled pines in most of the northern and central Rocky Mountain region, and it continues to spread throughout the southern Rocky Mountains.

The potential for catastrophic damage to the North American white pine resource had been recognized by plant pathologists working on WPBR in Europe, but unfortunately that concern was not enough to prevent independent introductions to both eastern and western North America. Western white pine proved to be highly susceptible to WPBR, with mortality rates exceeding 90% in what were once vigorous, well-stocked stands of nearly pure white pine. Many such stands in northern Idaho were relatively young, the result of natural regeneration after extensive, stand-replacing fires in the late 1800's and early 1900's.The story of western white pine in Idaho and the fight against blister rust can be found in "Return of the Giants" (Fins *et al*. 2001) published by the University of Idaho.

Hosts

All three of Idaho's five-needled pines are susceptible to WPBR and though western white pine is the most commercially valuable, whitebark and limber pines have immense ecological value within the forest types they inhabit. Even non-native five-needled pines, such as sugar pine and eastern white pine, planted as ornamentals in Idaho, are highly susceptible to WPBR.

Biology

C. ribicola has a complex life cycle, producing five spore types and requiring two non-related hosts to complete its life cycle. (Figure 1). The WPBR fungus must alternate between white pine and *Ribes* spp. (currants & gooseberries) to complete its life cycle . Research has recently shown some species of *Pedicularis* (lousewort) and *Castilleja* (Indian paint brush) can also be infected, but their role has yet to be determined. The fungus is not capable of spreading from pine to pine. Spores are produced on infected white pine in the early spring (Figure 2) and can disperse long distances to cause leaf infections on *Ribes.* The fungus then produces an aerially-dispersed, fragile spore on the *Ribes* that infects pine through minute openings (stomates) on the underside of its needles.

This stage is a critical period for the disease as each spore needs approximately 48 hours of high relative humidity (>96%) to germinate and penetrate a host needle. The branches closest to the ground are most vulnerable to infection. These branches are usually shaded, often covered by grass, and

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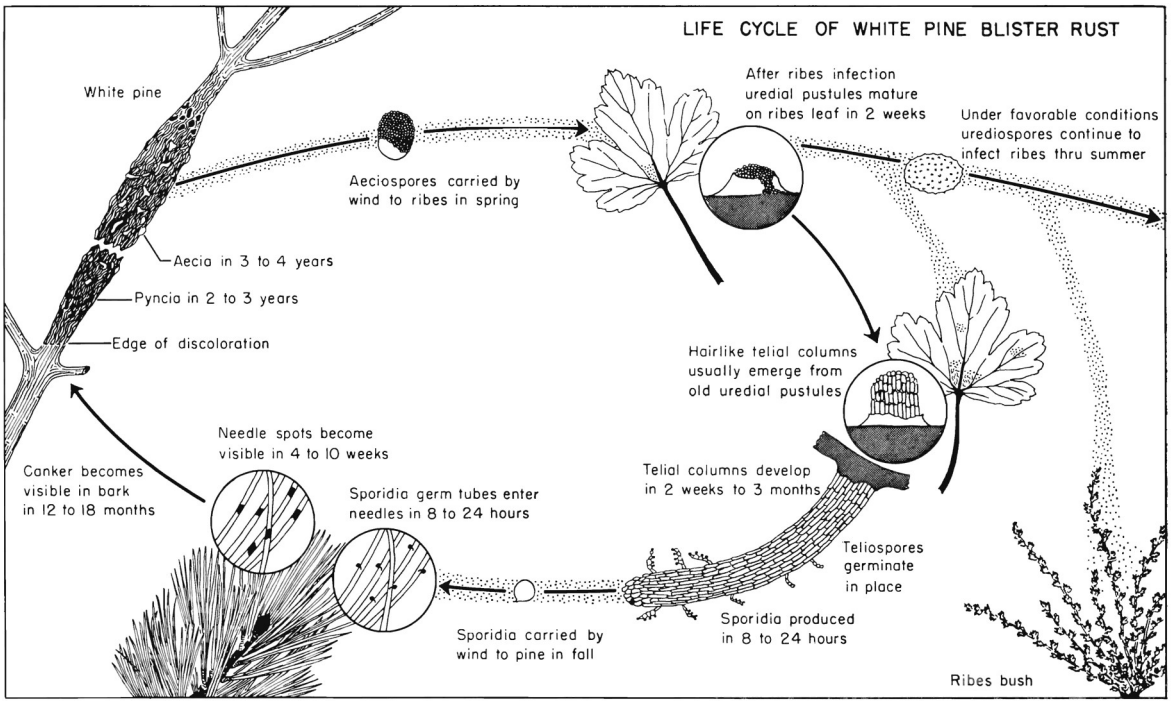

Figure 1. *Life cycle of white pine blister rust. (From: Miller et al. 1959).*

Figure 2. *Distinctive blister-like structures that form on cankers of infected white pine which produce spores that infect* Ribes *in early spring. (Photo by John Schwandt, USFS)*

are most likely to be covered by dew for the longest periods of time. Once infection occurs, the fungus grows down the needle to the base of the needle cluster and into the branch (Figure 3).

Figure 3. *Early stage of branch infection. Note cluster of dead needles in discolored area; this likely holds the needle where the infection began. (Photo by John Schwandt, USFS)*

Dead branches with brown or red needles, called "flags", are usually the first easily-observed symptom of WPBR. Flags are normally present throughout the year (Figure 4). The fungus grows down the branch towards the main stem at a rate of about two inches per year. As it grows, a sunken or swollen area of dead tissue, or canker,

Figure 4. *A typical "branch flag" caused by a blister rust canker girdling a branch (Photo by John Schwandt, USFS).*

develops. Cankers are often spindle-shaped, and are frequently covered with excessive amounts of resin. Cankers often have yellow or orange-colored margins that are especially visible when the bark is wet. During the spring and early summer, yellow to orange blisters develop on or near the margins; these contain the spores that will infect *Ribes* leaves.

Stem cankers have a distinctive diamond shape, often centered on a branch or needle. Abnormally high resin flow is usually associated with trunk cankers, causing long streams of white, dried resin to form around and below trunk cankers. In the spring and early summer, the yellow to orange blisters can often be seen around or within the margins of trunk cankers.

Damage

As the canker girdles the branch, the portion beyond the canker dies. These dead branches with brown or red needles, called "flags", are the first easily-observed symptom of WPBR. Flags are normally visible throughout the year (Figure 4). Stem cankers eventually extend around the entire circumference of the trunk and girdle the tree, killing it above the canker. White pines with dead tops usually have stem-girdling cankers just above the last group of live branches. Cankers that form low on the stem kill the entire tree. All sizes of trees are attacked and small seedlings can be killed rapidly. Generally, the larger the tree is at the time it becomes infected, the longer it survives after infection. On the *Ribes* shrubs, damage is usually confined to small leaf spots, but some defoliation may occur if the plant is severely infected.

Management

Use of stock with improved resistance (aka" "rust resistant stock")

The primary management tool against WPBR is the use of western white pine with improved rust resistance. The breeding program for resistant stock dates back to the early 1950s and resulted from the identification of low levels of naturally occurring disease resistance in native stands of western white pine. The program is ongoing and further improvement in rust resistance should result. The Inland Empire Tree Improvement Cooperative is still encouraging foresters to look for and report possible rust free "plus" trees for addition to the breeding program. Although preliminary tests of the rust-resistant stock showed that 65% of the trees would not become infected (Hoff *et al*. 1973), so far this level of resistance has not been consistently seen in the field. In a survey of 66 plantations infection levels ranged from 2% to 97%. So far, research has been unable to determine why this variation occurs.

Risk rating the site

Because of the wide variation in infection levels in stock with improved resistance, white pine should be grown on sites with a low to medium risk of infection. The following indicators of rust risk level have been developed based on information reported by Muller (2002) and others:

- Infection levels increased significantly at elevations over 4000 ft. and especially on slopes over 20%.
- Infection levels for sites on the western

redcedar /wild ginger habitat type was 60%; about twice that found on other habitat types.

- Infection levels on excavator piled units was significantly lower than on broadcast burned sites.
- Hagle *et al*. (1989) indicated that *Ribes* counts between 25 and 100/acre present a moderate risk of rust infection. Sites with over 100 *Ribes* per acre should not be planted with commercial quantities of white pine.
- Infection levels were significantly higher where shrub height exceeded 4.5 feet.

Plantation management

When possible, white pine regeneration efforts should utilize planting stock with improved rust resistance levels. Use stock with higher resistance levels if available.

Most lethal rust infections occur in the lower five feet of the tree (H. Kearns, personal comm.). Potentially lethal infections occur when needles on the main stem or on branches within 20 inches of the main stem become infected (J. Schwandt, personal comm.). The presence of tall shrubs seems to increase infection levels due to enhanced moisture levels. Shrub competition will significantly reduce seedling growth (Miller 2006) and there is some evidence that faster growing trees tend to have fewer lethal infections (Schwandt *et al*. 1994). Silvicultural treatments that result in increased seedling height growth will decrease the time when needles are present within 20 inches of the main stem below five feet (red zone) and should also reduce rust infections and mortality.

Preferred site preparation treatments to reduce the risk of infection include:

- Broadcast burning slash combined with light scarification or herbicide sprays to control competing vegetation.
- Mechanical scarification may be the best option if herbicides are not used to control vegetation in stands regenerated with white pine.
- Consider applying a soil-active herbicide such as atrazine or hexazinone **before** *Ribes* seed germinate to practically eliminate *Ribes* from the site. This treatment may also reduce or eliminate other species that originate from seed stored in the soil.
- Apply other herbicides to control other competing shrubs that can rapidly exceed the 4.5 ft. height threshold.

Pruning

Because of the conditions required by the rust spores to infect white pine needles (48 hours of high relative humidity), a high proportion of rust cankers are found within several feet of the ground, very commonly within just 1-2 feet, even on trees that are 20-40 feet tall. Therefore, pruning the lowest whorls of branches can greatly reduce the probability of the tree becoming infected. Remember, however, that pruning does not change the rust susceptibility of white pine; it only removes the branches ***most likely*** to be infected, not the ***only*** branches that can be infected.

Pruning to remove branch cankers in the lower crown has been shown to reduce rust-caused mortality in young white pine. Pruning when the trees are younger and smaller should result in saving more trees than later treatment. Pruning is not as effective once the stand has reached crown closure and after many of the most susceptible trees have died or have lethal infections that cannot be removed by pruning. Priorities for pruning are as follows:

- Stands with low infection levels by age 15 are a low priority for pruning or may not require pruning at all. These stands are nearing crown closure that will shade out the lower branches and cankers.
- Stands with high infection levels are also a low priority because of the high percentage of

lethal infections and the probability that the pruned trees will develop new infections above the pruned height.

- The stands between these extremes are the best candidates for pruning.

In under stocked stands, saving existing trees to increase harvest volumes becomes a priority that may justify both the risk and the pruning cost. In stands with higher densities, the rust infections may produce natural thinning. The lethally infected trees may take many years to die and will reduce growth on adjacent crop trees until they do.

It is vital to periodically monitor young stands for WPBR, even after pruning has taken place, to evaluate possible increases in rust levels. Rust infection can increase ***dramatically*** in a matter of just a few years, even in plantations with initially low levels of rust, and making the decision to prune, or deciding to prune higher, depends on having good monitoring data.

A publication that covers all aspects of pruning white pine, "*Pruning Western White Pine: A Vital Tool for Species Restoration*" (Schnepf and Schwandt 2006), is available from the University of Idaho and should be utilized as a desk reference and field guide by landowners and foresters.

Precommercial Thinning

Precommercial thinning should be conducted when crowns close and shade out smaller conifers, competing shrubs and the lower branches of white pine. Early thinning delays crown closure and the shading out of the shade intolerant *Ribes* and other competing shrubs. Results of a study showed pruning white pine combined with thinning resulted in about a 75% increase in survival over the next 30 years (Schwandt *et al*. 1994).

Since the disease does not spread from pine to pine, leaving infected trees in a stand should not significantly increase infection levels. Leaving infected trees as "ghosts" may reduce thinning costs, reduce the slash load, and help shade out the lower branches of white pine crop trees and reduce the risk of sunscald. If they die soon their competitive effect will be minimal. If they don't, they can compete with crop trees and reduce the overall growth of the stand. If there is a significant number of lethally infected trees in the stand, cutting them will reduce competition with the remaining crop trees and increase stand growth.

Leave-trees

In stands with mature, live white pine it is recommended to leave some of the best trees to help maintain genetic diversity and encourage natural regeneration where possible. These trees have been exposed to rust for many years and may possess resistance traits not yet incorporated into the breeding program. Guidelines for leaving up to ten trees per acre are provided in Schwandt and Zack (1996).

Useful Links

Forest Insect and Disease Leaflet

US Forest Service Region 1 Field Guide

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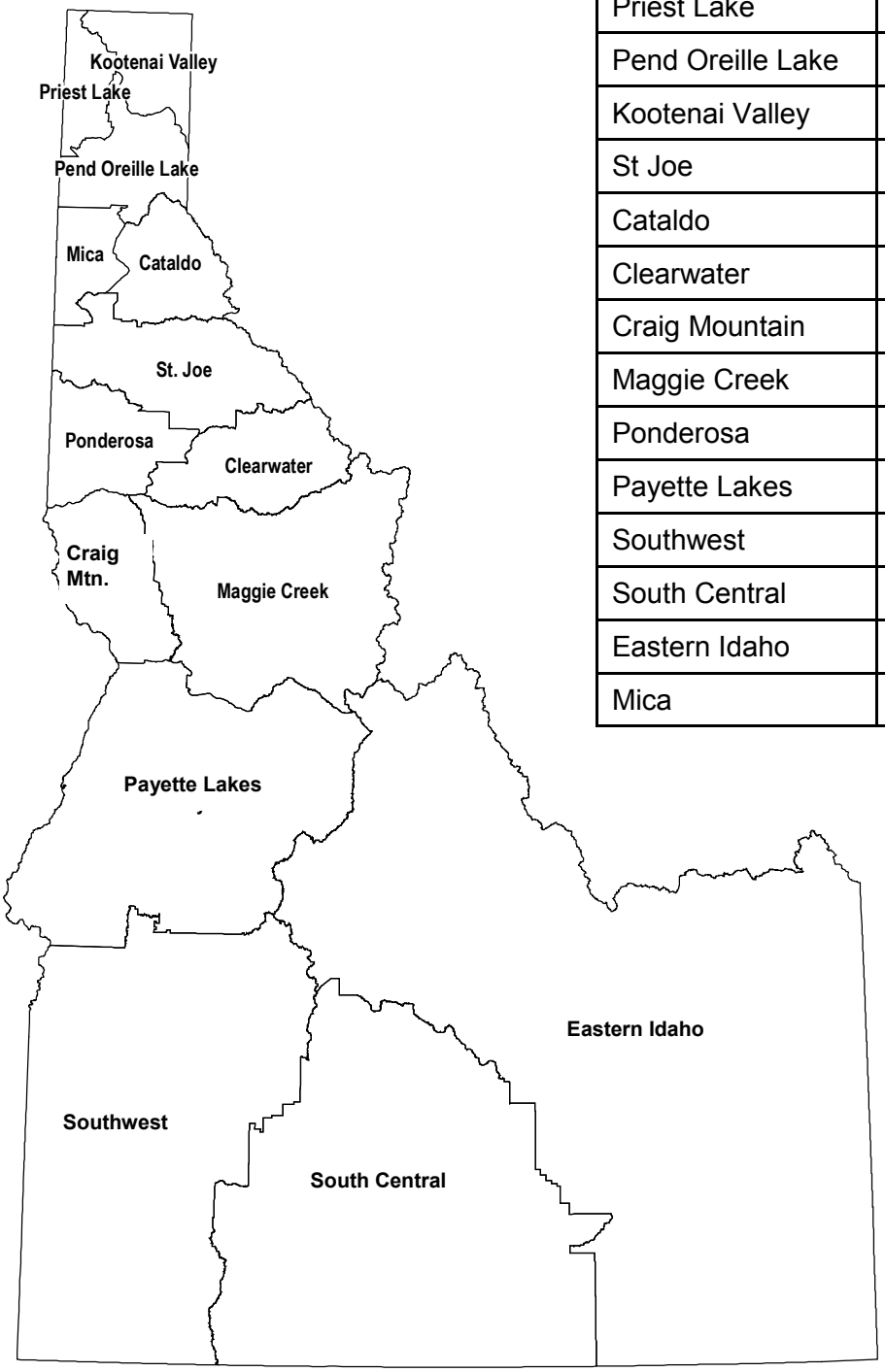
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