Assessing Potential Risks of White Pine Blister Rust on Western White Pine from Increased Cultivation of Currants

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ADDITIONAL INDEX WORDS. risk assessments, pest risk analysis, Forest Practices Code of British Columbia, forest management; forest disease, tree breeding and improvement, resistance, epidemiology, spacing, pruning, *Pinus monticola, Cronartium ribicola, Ribes*

SUMMARY. Introductions of white pine blister rust (WPBR, causal fungus: *Cronartium ribicola* J.C. Fischer) to eastern and western North America before 1915 caused such extensive damage that western white pine (*Pinus monticola* D. Don) was essentially abandoned as a manageable forest tree species for over 60 years. Recent results from WPBR resistance selection and breeding programs, and from field trials of tree spacing, pruning and bark excision treatments have supported efforts to increase establishment and to intensively manage western white pine. Western white pine is a desirable component in many forested areas because of its faster growth and much higher value compared to many other associated tree species. It also has a low susceptibility to armillaria root disease caused by *Armillaria ostoyae* (Romagnesi) Herink and laminated root rot, caused by *Phellinus weirii* (Murr.) Gilb. Some regulations, e.g., Forest Practices Code of British Columbia (BC) Act, require anyone who harvests timber on provincial forestland and uses western white pine for reforestation to either plant genetically resistant western white pine stock or prune susceptible young trees for protection. Risks of increased WPBR associated with increased commercial cultivation of gooseberries and currants (*Ribes* L.) have yet to be determined. However, major threats appear to include 1) increase in local amounts of spores for nearby infection of pines; and 2) possible introductions or development of new, virulent races of *C. ribicola*, particularly from eastern to Pacific northwestern North America. In view of these possible threats, we recommend that existing regulations and legislation should be amended, or possibly new measures enacted, to permit propagation and commercial cultivation only of varieties of *Ribes* that are immune or highly resistant to WPBR.

White pine blister rust—the name of the disease and the causal fungus—is important in both forestry and agriculture. Several species of currants (and gooseberries) are valuable horticultural shrubs for berry production and landscaping. Western white pine is one of the most valuable tree species both for its economic value and as a major constituent of forest ecosystems. WPBR was introduced to eastern and western North America before 1915 on infected white pine seedlings, and subsequently caused extensive damage to native white pines. Boyce (1948) gave an extensive account of the disease, including history and impacts. The fungus grows on both currants and white pine, and needs both hosts to complete its life cycle. It causes only late-season defoliation of currants but kills or severely damages white pines by infecting bark and causing branch mortality or flagging, top dieback, and lethal girdling of the stem of young trees. WPBR caused severe mortality of western white pine over extensive forested areas in western North America.

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Intensive management of western white pine is desirable in many forested areas of BC because of several features (Muir, 1988). These include rapid tree growth, very high value of timber and lumber (Random Lengths Publications, Inc., 1999), and low susceptibility to armillaria root disease (Morrison and Mallett, 1996; Shaw and Kile, 1991) and to laminated root rot (Nelson and Sturrock, 1993).

Some white pine species are valued as major components of wildlife habitat in mountainous ecosystems (Hoff et al., 1994). Recent surveys in the Vancouver Forest Region (Zeglen, 1999, 2000) indicated that a substantial proportion of white bark pine (*Pinus albicaulis* Engelm.) is infected by *C. ribicola*. Efforts are underway to identify resistant genotypes and possibly initiate a white bark pine, selection-breeding program (Hoff et al., 1994; Zeglen, 1999, 2000).

As a consequence of the introduction of WPBR, western white pine was essentially abandoned for over 60 years as a manageable forest tree species in the Pacific northwest region of United States and Canada. However, recent federal and provincial tree-breeding programs in British Columbia have developed genetically resistant white pine trees (Hunt, 1999). Similar programs have been established in the United States of America (Eramian, 1999; Kitzmiller and Samman, 1999; Sniezko, 1999) and in eastern Canada (Meier 1992). WPBR-resistant western white pines are now available and recommended for planting in BC (Hunt, 1994; Meagher and Hunt, 1998).

Susceptible western white pine trees can be protected from WPBR by pruning lower branches of young trees, and excising bark around nongirdling stem infections (Hunt, 1998). These results have supported efforts to reestablish and manage native stands of western white pine. Recently in BC, the Forest Practices Code Act of BC and regulations were developed to include a requirement that anyone who harvests timber and uses western white pine for reforestation must either plant genetically resistant stock or prune susceptible young trees for their protection (BC Ministry of Forests, 1996).

We have been concerned that recent proposals to increase commercial cultivation of currants could possibly result in renewed, damaging epidemics of the WPBR on white pines. Several states in the United States of America have regulations that prohibit cultivation of *Ribes* species (McKay, 2000). However, many jurisdictions, including Canada, have no regulations concerning acceptable varieties of *Ribes* species for commercial cultivation, nor measures to restrict their movement between provinces or states. In principle, before allowing increased cultivation of certain *Ribes* species, the risks of increased disease occurrence and damage to white pines and currants should be assessed.

Our objective in presenting this paper is to highlight some background information and approaches that we believe should be considered when evaluating proposals for increased cultivation of *Ribes* species, based on our experience with managing western white pine in BC and research on WPBR.

Risk assessments and analyses

Risk assessments are frequently used in a variety of subject areas or by different expert groups for several purposes (Morgan and Henrion, 1990). They are often a prerequisite for decisionmaking or formulating policy (Keeney, 1982). Two different risk assessment approaches appear relevant for assessing risks of increased cultivation of *Ribes* species and WPBR: local risk assessments for specific forest sites or ecosystems; and formal pest risk assessments by a regulatory agency [Food and Agriculture Organization of the United Nations (FAO), 1996].

Forest site assessments

Local risk assessments for specific forest sites or ecosystems can be based on a variety of procedures ranging from *ad hoc* to legally required assessments defined or required by local regulations. Legally required procedures vary from province to province and between states. In BC, assessment of risks for forest management is tied to procedures for forest development planning and requirements for site-specific prescriptions for harvesting, regeneration and stand tending, e.g., spacing or thinning, pruning and fertilizing. Under the Forest Practices Code of BC Act, district managers can require a local survey of incidence of potentially damaging insects and diseases for a forest area planned for harvesting. The information, including an evaluation of the local hazard for WPBR infection of the succeeding young trees, is used to develop a silvicultural prescription.

In BC, licensees (or the provincial government for its small-scale business-harvesting program) must establish a new crop of free-growing healthy trees. This involves applying appropriate harvesting, establishing and tending practices, and assessing the new stand of trees at about age 8 to 15 years. At that time the new stand is assessed to determine if it is stocked according to terms of the prescription, with appropriate species at the required density or number of stems per hectare, that are healthy or free from damaging levels of insects and / or diseases. When the district manager accepts the stand as free growing, protecting and managing the new stand becomes the responsibility of the provincial government (except where long-term tree farm or woodlot licenses are in effect). Therefore, a new stand of healthy trees must have a high probability of survival to maturity.

For WPBR in BC, regulations require that all western white pines in reforested areas must be pruned to protect them from WPBR by removing all live branches to a specified height, usually about 2.5 m (8 ft), except if the trees were genetically resistant stock. If the district manager determines that the risk of WPBR infection is low, then s / he can grant an exemption to the requirement for pruning. These requirements were based on research findings that the critical period for WPBR in the life of a forest is the establishment phase, up to approximately age 15 years. Hunt (1983, 1998) and others found that most WPBR infection that results in tree death occurs before tree age 20 years. On level to moderate (up to 20% or 30%) slopes, results of several studies indicated that most lethal infections occur at or below a height of 2.5 m on trees. On steeper slopes, infections may occur higher in the upper crowns of trees, but most of these only kill limited portions of the tree crown, and usually are not lethal. Genetically resistant stock does not have to be pruned.

Unless immune or highly resistant varieties of *Ribes* species were propagated, there is a possibility that management of native stands of white pine, and durability or longevity of selected, WPBR-resistant tree genotypes could be put at more risk by any increased cultivation and interprovincial or international shipments of currants. These risks include 1) increased local spore loads; 2) spread of currently isolated, more virulent races of WPBR; and 3) development of new WPBR races.

INCREASED SPORE LOADS. White pines are infected only by the basidiospore stage of the WPBR fungus that develops on currants. Several studies have surveyed local occurrences and species of *Ribes* and local potential hazards for WPBR (Hunt, 1983). Hitchcock et al. (1961) lists 32 *Ribes* species for the Pacific northwestern region. Most have been tested over several years and they display a wide range of susceptibility. None were found to be immune. The two most susceptible species, *R. hudsonianum* Richards (*R. petiolare* Dougl.) and *R. bracteosum* Dougl. were found (Kimmey 1938) to be about half as susceptible to WPBR as black currants (*R. nigrum* L.). Native currant species often are locally abundant in riparian zones near creeks, and in areas which have been disturbed by fires or chronic root disease infestations (Hunt, 2000). In forested areas, seeds of native *Ribes* can persist for decades in the organic soil horizon, and following disturbances such as fire or harvesting can germinate and quickly reestablish as shrubs. The ability of native *Ribes* species to regenerate rapidly in forest areas was a major reason why large-scale, extensive programs to eradicate *Ribes* species in western North America were judged unsuccessful and largely abandoned. However, in Maine, Ostrofsky et al. (1988) reported that a 70-year regional *Ribes* species eradication program significantly reduced eastern white pine (*P. strobus* L.) infection from 9% of the trees in untreated stands to 4% in treated stands.

Although most *C. ribicola* infection of white pine is expected to occur in close proximity to infected *Ribes* species, incidence or severity of WPBR on pine has been correlated only approximately with local occurrences of infected *Ribes* species. WPBR basidiospores are thin-walled and relatively short-lived so that generally most infection of forest trees is believed to occur within about 100 m (300 ft) of infected native currants. Hunt (1983) attributed a lower incidence of infection in BC (compared to levels in Idaho and Montana) to a lower frequency of occurrence of *Ribes* plants, but data were not given. Ostrofsky et al. (1988) found only two *Ribes* plants—one in treated and one in untreated stands—in the 90 stands of eastern white pine that they surveyed. In some instances infection of eastern white pine is not closely related to the proximity of infected *Ribes* species, but is better explained (van Arsdel, 1965) by dispersal patterns of basidiospores by nighttime breezes and air movements. Van Arsdel (1965) suggested that spores could be dispersed up to 17 km (10 miles) from *Ribes* species to eastern white pines. Spores could be moved down slope by nighttime flows of air from ridges or higher slope positions to lower areas, and uplifted or lofted from valley bottoms to upper-slope sites. Therefore, we judged that cultivation of susceptible *Ribes* species in valley bottoms in mountainous areas of BC could pose a threat to western white pine stands at higher elevations within a distance of 10 to 20 km (6 to 12 miles).

Spore loads are also important for breeding and selection programs. Programs for western white pine have generally emphasized broadly based genetic resistance. Resistance is generally believed to be linked to reduced needle infection, or more recently, to other mechanisms such as slow canker growth and tolerance to cankers (Hunt, 1997). Recently, there also have been attempts to incorporate specific-gene immunity in western white pine to specific races of the fungus. For some broad-based genetic mechanisms, effectiveness of resistance decreases as spore loads increase. Growing susceptible currants near resistant western white pines could overcome their resistance by increased deposition of infectious spores.

SPREAD OF ISOLATED, MORE VIRULENT RACES OF WPBR. Selection and development of WPBR-resistant white pine has been based on inoculations using locally collected leaves of infected, native *Ribes* species. Although there are instances where new races of the fungus have developed in forest environments and damaged resistant trees, spread of these new races appears to be limited (Kinloch, 2000). WPBR is believed to be capable of spreading in one season to distances of 500 km (300 miles) via aeciospores that are produced on infected pines and infect *Ribes* species, and urediospores produced on *Ribes* that only infect *Ribes* species (Boyce, 1948). Although most long-distance spread probably occurs on native, wild species of *Ribes* species, increased commercial cultivation of susceptible *Ribes* species could facilitate the spread of these more virulent races of WPBR in forests of western and eastern North America.

Hamelin (1998, 1999) found significant and major differences in genetic makeup of populations of the WPBR fungus in eastern and western North America. These differences suggested that there also could be major differences in virulence between the eastern and western populations of WPBR (Hunt and Meagher, 1989). Possibly, increased plantings of susceptible *Ribes* species in the central North America Great Plains and Prairies regions could form an intercontinental bridge that would facilitate east–west (or west–east) spread of WPBR. This could result in new outbreaks of more virulent races of the fungus. Therefore it would be desirable to permit propagation and commercial cultivation of only immune or highly resistant *Ribes* species in this region. In addition we should prohibit movement of any infected or susceptible white pines or nondormant *Ribes* plants from eastern to western North America, and vice-versa.

NEW WPBR RACES. Long-term successful use of genetically resistant western white pine in Pacific northwestern North America forests is predicated on maintaining genetic stability of *C. ribicola*. We should avoid creating conditions that could facilitate mixing of genetically diverse races and fostering development of new races of this rust. In the 85 years since WPBR was established in North America, large numbers of susceptible white pine trees have been killed, and the remnant western white pine population is believed to be more resistant. However, there is always a concern that new races of the fungus could develop and damage genetically resistant white pine stock. We expect that a genetically stable population of the rust fungus will be maintained on native white pines in reserves (parks, etc.) throughout its range in BC. *C. ribicola* gene pool reservoirs on these wild white pines should dampen genetic selection resulting from using resistant white pine stocks. Another factor that favors this approach is that spore loads from locally infected *Ribes* plants generally are expected to decrease as forest trees grow taller and understory shrubs are shaded and suppressed (Boyce 1948). However, nearby commercial cultivation of susceptible *Ribes* species could increase spore loads and increase the possibilities of development of new virulent WPBR.

Regulatory assessments

Recently an analysis was undertaken (J.E. Hollebone, personal communication) by the Canadian Food and Inspection Agency to assess risks and develop import and domestic movement requirements for cultivating barberry (*Berberis* L.) plants, alternate hosts for black stem rust of wheat (*Puccinia graminis* Pers.). The issues appeared very similar to those associated with proposals to increase cultivation of *Ribes* species. Black stem rust has two groups of alternate hosts: plants of the genera *Berberis*, *Mahonia* Nutt. and *Mahoberberis* C.K. Schneid; and various cereals such as wheat (*Triticum aestivum* L.), barley (*Hordeum vulgare* L.), oat (*Avena sativa* L.), rye (*Secale cereale* L.) and grasses (*Agropyron* species.). Local barberry plants produce spores that infect wheat earlier in spring than the usual influx of spores from southern regions, resulting in more severe damage. Also, infection of local barberry plants results in increased hybridization and development of new races of the rust that overcome resistant wheat varieties. In wheat-growing areas, barberry plants have been prohibited and actively eradicated for many years. As a result of the analysis, it was proposed (currently under review) that only varieties of barberry that are immune or highly resistant to the rust should be permitted for cultivation, sale and movement within Canada, provided that they were properly tested and labeled. There was a concern that immune barberry could hybridize readily with nearby wild, susceptible barberry plants, but it was envisioned that provincial or local programs to eradicate susceptible barberry in wheat-growing areas would continue, and that immune barberry would be used mostly for ornamental plantings in urban areas. It appeared very desirable to recommend that a similar approach be taken to permit and regulate propagation and cultivation of only immune or highly resistant *Ribes* species.

In our opinion, proposals to increase *Ribes* cultivation, and to change current regulations to permit cultivation, warrant an extensive analysis of the associated risks of increased damage by WPBR, similar to that done for cultivation of barberry and black stem rust. Although WPBR is not classified as a quarantine disease, an extensive analysis similar to a formal pest risk analysis (FAO, 1996) should be undertaken. The analysis will provide a substantial basis to determine whether local regulations should be maintained, amended or deleted. The analysis should include several factors, including those that were discussed in this paper and by others at the 1999 Corvallis, Ore., workshop. Considerations include the value of white pines and *Ribes* species (native wild and cultivated species and varieties) both for their cultivated and derived products and their value in forest ecosystems and ornamental plantings. The importance of recent programs to select and propagate genetically resistant white pines and investments in silvicultural treatments to protect young white pine stands should also be considered. Immunity or susceptibility of varieties of *Ribes* plants; amount of spores produced on susceptible *Ribes* species, particularly new varieties for cultivation; and distances or probability of basidiospore dispersal from infected *Ribes* species (both wild species and cultivated varieties) to white pine need to be determined.

Potential risks of increased commercial cultivation of currants to management of white pines are largely unknown. The magnitude and severity of damage from previous introductions of the fungus to North America strongly indicate that we should undertake studies or evaluations to determine such risks. Government and other specialists, and members of scientific working groups and advisory or regulatory committees should encourage or endorse studies to evaluate these potential risks.

Legislation and regulations

Pending results of various assessments and research to determine risks, it would be prudent to reexamine our policies and regulations on the cultivation and transportation of currants. We should develop more effective regulations or policies to reduce potential risks, wherever warranted and feasible. In contrast to apparent indifference or pessimism about protecting forest and agricultural resources that prevailed in North America before 1915, most agencies and governments now recognize the necessity of assessing risks and ensuring adequate protection from damaging insects and diseases, both native to North America and introduced from other continents. Therefore, we are confident that these groups will carefully assess the risks of increased cultivation of currants, and will consider appropriate amendments, if necessary, to existing legislation and regulations to adequately protect white pines. In our opinion, a key provision is to permit propagation and commercial cultivation only of varieties of *Ribes* species that are immune or highly resistant to WPBR where white pine species could be threatened.

Conclusions

We are concerned that increased cultivation of currants could jeopardize selection and breeding programs for developing resistant white pine trees, and possibly undermine use of the selected, WPBR-resistant, western white pine genotypes in reforestation programs. Both regulatory and forest-site analyses are essential to assess risks of WPBR damage from increased cultivation of *Ribes* species. Local forest site risk assessments are necessary to ensure that forest harvesting and establishment practices result in healthy western white pine that have high probability of long-term survival. Regulatory, broad-scale risk assessments are necessary to assess overall risks of damage, and to develop appropriate, fair laws and regulations for plant movement and cultivation. In our opinion, a crucial issue is to ensure that increased commercial cultivation of *Ribes* species will not jeopardize current programs to reestablish western white pine as a major component of Pacific northwestern forest ecosystems. We recommend propagation and commercial cultivation of only immune or highly resistant species or varieties of currants in situations where white pines could be threatened. This will reduce the chances of new occurrences and spread of virulent races of *C. ribicola*.

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