White Pine Blister Rust in Vermont: Past, Present, and Concerns for the Future

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SUMMARY. White pine blister rust (WPBR) (*Cronartium ribicola* J. C. Fischer) has been present in Vermont and other northeastern states since the early 1900s. The fungus is commonly observed on currants and gooseberries (*Ribes* L.) every year, but incidence varies on eastern white pine (*Pinus strobus* L.). Our general impression has been that Vermont has had a relatively low level of infection on eastern white pines; however, we recently found rust incidence in Christmas tree plantings in northern Vermont to range from 10 to 42% (average 20%) based on 721 trees surveyed. Also, in pole-sized stands in southern Vermont, incidence ranged from 12 to 46% (average 32%) and 76% of these trees had main stem infections. In the southern survey, 98% of wild ribes plants had varied amounts of both urediniospores and teliospores. These preliminary survey data suggest that incidence of WPBR may be more significant than previously thought and therefore, additional survey work is needed. We screened cultivars of *Ribes* for susceptibility to WPBR. Eighteen cultivars were inoculated in the field with a mass collection of aeciospores of *C. ribicola*. The percentages of leaf area infected ranged from 0 to 49 for the urediniospore stage and from 0 to 55 for teliospores. The gooseberry (*Ribes uva-crispa* L.) 'Welcome' had the highest percentage of leaf area with urediniospores, while black currants (*R. nigrum* L.) 'Coronet,' 'Consort,' and 'Crusader' had no visible infection. Presently, Vermont has no WPBR regulations. However, previous federal laws did restrict black currant cultivation. Little is known about the genetic diversity of WPBR or its potential for change. Caution must be used when considering any cultivation of *Ribes* for the purpose of producing fruit because our valued white pine resources could be negatively impacted.

White pine blister rust caused by *Cronartium ribicola* (Arthur, 1934) needs no introduction to foresters or plant pathologists. It has a well-known history as a destructive exotic pathogen in both Europe and North America. This rust is the main cause of timber loss for certain species of white pine [eastern white pine, sugar pine (*Pinus lambertiana* Dougl.) and western white pine (*P. monticola* Dougl. ex D. Don)] and has been responsible for creating major ecological change in the pine forests of North America (Hagle et al., 1989; Ketcham et al., 1968; Merrill, 1988; Mielke, 1943).

In northeastern North America, eastern white pine forests remain a highly significant part of the landscape and rural economy. In Vermont, the 1998 growing stock stumpage value of eastern white pine was estimated to be about $290 million with an annual postharvest value of about $56.13 million. In addition, pines have a substantial value associated with the ornamental and nursery trade (unpublished data). Therefore, we should consider eastern white pine as having a diversity of multiresource values important to our value-added forest industries and our rural economy.

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In addition, this species is invaluable; it adds substantial diversity and aesthetic interest to the picturesque hardwood forests and landscapes of our state.

WPBR is a heteroecious fungus that alternates between five-needle soft pines and *Ribes* (Arthur, 1934). This rust has been known in North America since about 1900, but some pines and *Ribes* may have been infected prior to 1900 in northeastern North America (Benedict, 1981; Spaulding, 1911). WPBR was first reported in Vermont on nursery stock in 1909 (Spaulding, 1911). The rust is commonly observed on *Ribes* annually but rust incidence on pines seems to vary by year and geographical location. Our general impression has been that eastern white pines have had a relatively low incidence of infection when growing in forested areas in Vermont (unpublished data).

Vermont has no current WPBR control regulations that restrict *Ribes*. However, previous laws did restrict the growing of black currant although other species were allowed if the grower could certify that no valuable white pines grew within 900 ft (274 m) of the planting site. Vermont previously required shipping permits for all in-state and out-of-state movement of *Ribes* but this requirement was dropped in 1996. These permits were primarily designed to inform the public about the serious nature of WPBR but they also provided a record of nursery sales of *Ribes*. Vermont also mandated a *Ribes*-free zone around their state tree nursery until it closed in 1994.

Genetic diversity of WPBR and its potential for change is not well understood. The commercial cultivars of *Ribes* are also genetically diverse and should be considered exotic plants when introduced to the landscape. These cultivars are selected for hardiness, growth robustness, fruitfulness, and in some instances disease resistance. Many of these cultivars may appear resistant to the current races of WPBR but it is unknown how resistance will change over time. These cultivars have potential to interbreed with native populations or with other cultivars of *Ribes*, and progeny from these out-crosses will be disseminated across the landscape and may bear little resemblance to their parentage in terms of growth habit or disease resistance.

WPBR continues to cause serious damage to all species of susceptible pines throughout their respective ranges in North America (Kinloch and Dulitz, 1990). Because of concern for the long-term health of our native pines and due to the recent interest by small fruit growers in planting exotic cultivars of currants and gooseberries,

Table 1. Incidence of white pine blister rust on Christmas tree-sized eastern white pine in northern Vermont, August 1999. All trees were sheared annually and had basal pruning except plots 3 and 5.

Plot	Trees (no.)	Infection no.	Infection %	Infection type: Twigs (no.)	Infection type: Branches (no.)	Infection type: Stems (no.)	Total infections (no.)	Total infections/ infected tree (no.)	Tree size (ft[z])
1	119	10	10	0	11	8	19	1.6	6–10
2	131	50	38	0	86	21	107	2.1	6–9
3	31	13	42	1	18	6	25	1.9	10–14
4	71	7	10	0	7	1	8	1.1	7–9
5	319	48	15	1	73	18	92	1.9	6–10
6	50	12	24	4	9	6	19	1.6	7–8
Total	721	142	20	6	204	60	270	1.9	---
Average				2%	76%	22%			

[z]1 ft = 0.3 m.

Table 2. Incidence of white pine blister rust on pole-sized eastern white pine in southern Vermont, August 1999.

Plot	Trees (no.)	Infection no.	Infection %	Infection type: Twigs (no.)	Infection type: Branches (no.)	Infection type: Stems (no.)	Total infections (no.)	Total infections/ infected tree (no.)	Tree size (ft[z])
1	24	10	42	0	4	9	13	1.3	10–20
2	24	7	29	0	0	7	7	1.0	25–50
3	24	8	33	0	4	6	10	1.2	20–40
4	24	11	46	0	3	10	13	1.2	15–25
5	24	11	46	0	1	11	12	1.1	20–50
6	24	3	12	0	1	2	3	1.0	20–50
7	24	4	17	0	0	5	5	1.2	20–40
8	24	8	33	2	2	4	8	1.0	5–40
Total	192	62	32	2	15	54	71	1.1	---
Average				3%	21%	76%			

[z]1 ft = 0.3 m.

Table 3. Incidence of white pine blister rust on wild *Ribes* species in southern Vermont, August 1999.

Plot	Plants (no.)	Stems (no.)	Infected plants (no.)	Infection[z] (%)	Site surveyed
1	12	26	12	100	Stonewall near road
2	11	21	11	100	Stonewall near road
3	5	14	5	100	Stonewall near road
4	7	53	7	100	Stonewall / hedge
5	6	16	6	100	Stonewall
6	1	3	1	100	Stonewall / hedge
7	4	8	4	100	Stonewall / hedge
8	4	11	3	75	Roadside wet area
Total	50	152	49	---	
Average	6.2	3.0	---	98	

[z]Uredia and telia present.

we designed a preliminary survey to assess incidence of WPBR. In addition, we studied relative WPBR susceptibility of certain *Ribes* cultivars. The main objectives of this paper are to present these findings and to express concern about the future of our white pine resource in the presence of *Ribes* and WPBR.

Materials and methods

In August 1999, we conducted a preliminary survey to determine the relative incidence of WPBR on living eastern white pine trees and native *Ribes* species. A total of six survey sites were located in Christmas tree plantations in northern Vermont and an additional eight sites were in naturally regenerated stands in the south. A transect method was used to survey trees at each site. All trees were evaluated for number of WPBR infections (twig, branch, and main stem) and tree heights (feet) were estimated. All trees from a randomly selected row of trees were evaluated in each of the six northern plantations but only the first 24 trees in a 66 ft (20.1 m) wide transect were evaluated at each site in the south. We also evaluated the incidence of WPBR on native populations of *Ribes*. using a transect method but restricted the survey to habitats conducive for growth of *Ribes* (i.e., stone walls and moist areas).

In 1988, we screened 18 *Ribes* cultivars (see Table 4) for relative susceptibility to WPBR and a brief abstract was published (Dorrance and Bergdahl, 1990). All cultivars were grown in the field at Jericho, Vt., and were initially inoculated in early May with a mass collection of aeciospores collected from three different cankers from each of five different grographical regions in Vermont. Thereafter, all new infections were the result of natural infection in the field. To evaluate susceptibility, five leaf samples were randomly collected from each cultivar during mid-July and late August and the percentage of leaf area covered by urediniospores or teliospores was determined for those dates, respectively. Analysis of variance and Duncan's multiple range test were used to determine significance of these leaf area data.

Results and discussion

WPBR is commonly observed on *Ribes* every year but incidence of infection seems to vary on eastern white pine. This variation may be due to the influence of the many environmental parameters affecting the epidemiology of WPBR (Charlton, 1963; Van Arsdel, 1965). In our recent survey (August 1999), we found rust incidence in Christmas tree plantings in northern Vermont to range from 10 to 42% (average 20%) based on 721 trees surveyed (Table 1). In total, 22% of the infected trees had lethal main stem infections; whereas, 76% and 2% of the trees had branch and twig infections, respectively. In southern Vermont, incidence of infection ranged from 12% to 46% (average 32%), and 76% of the infected trees had main stem infections; whereas, 21% and 3% of the trees had branch and twig infections, respectively (Table 2). The average number of infections per infected tree was 1.1 for the older trees in the south as compared to 1.9 for northern trees. Branch infections may eventually become lethal main stem infections once the fungus has the opportunity to grow through an infected branch into the main stem. Therefore, the much higher percentage of main stem infections on the older trees in southern Vermont is most likely the result of the fungus having sufficient time to grow into the main stem.

Our survey results suggest WPBR may be more significant in Vermont than previously thought. We are especially concerned about the high percentage of potentially lethal main stem infections found on the older pines. Based on these preliminary results, we believe that a more comprehensive survey is needed and should be designed to determine both incidence and severity of WPBR in the major eastern white pine growing regions of our state. This more comprehensive survey should be designed to serve as a baseline for incidence of WPBR infection prior to any proposed commercial planting of *Ribes* within our pine forest regions.

The incidence of infection was also recorded for all species of wild *Ribes* found along survey transects only in southern Vermont. About 98% of the surveyed plants were infected with WPBR and all had both urediniospores and teliospores present by late August 1999 (Table 3). These wild plants were generally found growing in the understory along stone walls or in moist soils. These wild plants were not vigorous (average three stems per plant) nor were they highly fruitful in comparison to commercial cultivars.

Of the 18 *Ribes* cultivars screened in mid-July, the gooseberry 'Welcome' had the highest percentage of leaf area affected with urediniospores; while black currants 'Coronet,' 'Consort,' and 'Crusader' had no visible infection (Table 4) (Dorrance and Bergdahl, 1990). The gooseberries 'Redjacket' and 'Pixwell' had the highest percentage of leaf area with teliospores; while the red currents (*R. rubrum* L.) 'Cherry' and 'Consort' had no apparent infection (Table 5). The black currants 'Cornet,' and 'Crusader;' the red currant 'Wilder;' and the gooseberries (*R. uva-crispa*), 'Canada 0273', 'Green Hansa' and 'Whitesmith', were completely defoliated by late August. Their leaf area with teliospores could not be evaluated.

Table 4. Percentage of leaf area with urediniospores of *Cronartium ribicola* on cultivars of *Ribes*.

Cultivar	Leaf area[z] (%)
Welcome	49 a[y]
Redjacket	31 b
Green Hansa	28 bc
Poorman	26 bc
Wilder	20 bcd
Champion	20 bcd
Pixwell	15 bcd
Canada 0273	14 bcd
Spinefree	14 bcd
Whitesmith	10 cd
Friedl	9 cd
Red Lake	6 d
Jumbo	4 d
Cherry	4 d
White Currant	3 d
Consort	0 d
Crusader	0 d
Coronet	0 d

[z]Based on five leaves per plant.
[y]Percentages followed by the same letter are not significantly different using Duncan's multiple range test (p = 0.05).

Table 5. Percentage of leaf area with teliospores of *Cronartium ribicola* on cultivars of *Ribes* L.

Cultivar	Leaf area[z] (%)
Redjacket	55 a[y]
Pixwell	46 ab
Welcome	25 b
Poorman	24 bc
Spinefree	9 bc
Friedl	8 bc
Jumbo	7 bc
Red Lake	6 bc
White Currant	4 bc
Champion	1 c
Cherry	0 c
Consort	0 c

[z]Based on five leaves per plant.
[y]Percentages followed by the same letter are not significantly different using Duncan's multiple range test (p = 0.05).

Resistance to WPBR in certain white pine phenotypes has been known since about 1950 and disease resistance breeding programs have been in place since that time (Bingham, 1983). However, the genetics and mechanisms of disease resistance are yet to be understood and evidence is mounting concerning genetic variation in the pathogen (Hamlin, 1998; McDonald and Dekker-Robertson, 1998). In addition, various cultivars of *Ribes* have substantial phenotypic variation in WPBR resistance (Anderson and French, 1955; Dorrance and Bergdahl, 1990; Hummer, 1997). Some commercial cultivars of *Ribes* appear highly resistant to this pathogen but the nature of this resistance and its transferability to other species or cultivars is not understood.

Early attempts to slow the spread of WPBR were primarily aimed at controlling *Ribes* populations. This control effort was finally determined not to be efficacious in western North America and was discontinued in 1966 (Ketchum et al., 1968); however, reductions in *Ribes* populations have been reasonably successful in controlling WPBR on eastern white pine (Laflamme et al., 1998; Ostrofsky et al., 1988).

Eastern white pines are a long-lived, valuable resource in the forests of North America. WPBR is a virulent exotic pathogen that is lethal to most white pines but not to *Ribes*. Currently, the possibility of growing commercial cultivars of *Ribes* for small fruit production is being discussed. We believe that such an endeavor would be very risky for eastern white pines based on current understanding of the genetic, epidemiological, and host–parasite relationships of WPBR. Our major concerns about the future potential of WPBR in the presence of its hosts include but are not limited to the following:

1) Commercial *Ribes* cultivars are not part of the natural ecosystem and therefore should be considered exotic plant introductions. These cultivars may produce offspring (seeds or pollen) that could be disseminated into forested areas. The resulting plants could eventually become a factor in the epidemiology of WPBR. Progeny from some WPBR-resistant cultivars are not resistant to this rust (G. Hudler, personal communication). Also, little is known about the diversity and pathogenicity of the different races of *C. ribicola* on the different species and cultivars of *Ribes*. We think this is an area that will require a substantial amount of research.
2) The planting of WPBR resistant *Ribes* cultivars will provide additional selection pressure on *C. ribicola*. This pressure will eventually elicit and select for change in the pathogen. This change may have a significant, negative impact on either or both of its hosts. Also, the many so-called resistant cultivars may not be resistant to all strains of *C. ribicola*. This is also an area that will require substantial study.
3) Forest industry has had little if any involvement in this discussion concerning the proposed commercial production of *Ribes* as a fruit crop. We think the value of white pine will far exceed the values associated with growing *Ribes* fruit. Therefore, it is very important that the growers of susceptible white pines be involved in all phases of this WPBR / *Ribes* discussion.
4) We think selected *Ribes* cultivars could be grown if they were highly resistant or immune to WPBR and only could be asexually propagated (i.e., no viable seed or pollen produced). However, any form of apomixis is unknown in the genus *Ribes* at this time but cultivars of this type possibly could be planted without risk to susceptible white pines for as long as WPBR resistance was maintained by these cultivars. Once resistance is lost, these cultivars would need to be removed from production areas.
5) Due to the serious nature of WPBR and its significant potential for a negative impact on our highly valued pine resource, we think it is in the best interest of all to be cautious when considering the commercial production of *Ribes* fruit in our forested areas.

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