Persistence of Major Gene Resistance in Western White Pine (*Pinus monticola*) in British Columbia

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White pine blister rust, a devastating disease caused by the rust pathogen *Cronartium ribicola*, has been attacking and killing western white pines (*Pinus monticola*) for more than 100 years since its introduction to the Canadian province of British Columbia (BC) (Hunt 2009). There is a single dominant (major) gene for resistance (MGR) that produces a hypersensitive infection spot similar to that observed in resistant reactions in other plants attacked by rust pathogens. It was first found in a limited geographic area of southern Oregon, USA, known as the Champion Mines (Kinloch et al. 1999). Resistant Champion Mines clones were established at Dorena, Oregon, in the mid-1960s; since then, however, the pathogen has circumvented this resistance at Dorena and other areas in southern Oregon (Kinloch et al. 2004). This MGR resistance was imported to BC in seed collected from Dorena. Resistance came from seedlots from two geographic areas: (1) open-pollinated (OP) Champion Mines clones, and (2) OP Washington State, USA clones. Seedlings were planted into nine root disease sites in 1986 and 1987 throughout BC. Details of the plantation design using these 2 pine sources and 12 other provenances can be found in Hunt (1987) and Meagher and Hunt (1998). The first seedlot was also planted into three coastal and three interior provenance trials in 1988 (see Meagher and Hunt 1998) and the second seedlot into three demonstration plantations in 1994. These trees have been examined for growth and blister rust periodically over the years. At the previous IUFRO rust meeting held in OR in 2001, we (Hunt et al. 2004) reported that this resistance appeared to be persistent. In this report we provide a 2014 update.

The growth of the Washington trees was consistently superior to that of the Champion Mines-derived trees. At age 10 to 12, it was apparent in several of the plantations that about 50 percent of the trees in each of these two seedlots were rust resistant. Seed was collected from a sample of these canker-free trees. By using the protocol of inoculating 50 seedlings/parent as recommended by Bro Kinloch, it was determined that 50 percent, or all, of their offspring produced hypersensitive needle reactions indicative of heterozygous and homozygous MGR resistance, respectively. The MGR resistance within the Washington trees was attributed to pollination at Dorena from Champion Mines clones, because none of these trees was homozygous resistant. Rust surveys and observations in 2013 and 2014 of six root disease sites continued to demonstrate that there was no apparent failure of MGR resistance (table 1; trees missing or those killed by other agents were omitted from the dataset, and MGR and neighboring geographic sources were pooled). The six provenance sites have not been formally inspected since 2001. The demonstration plantation

In: Schoettle, Anna W.; Sniezko, Richard A.; Kliejunas, John T., eds. 2018. Proceedings of the IUFRO joint conference: Genetics of five-needle pines, rusts of forest trees, and Strobusphere; 2014 June 15–20; Fort Collins, CO. Proc. RMRS-P-76. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 245 p.

Table 1—Blister rust infection on pooled sources of western white pine across seven plantation sites.

Site	Canker-free (%) white pine from four pooled sources[a]			
	Pool #1	Pool #2	Pool #3	Pool #4
Marl, 51°31 W117°25	87	89	88	53
Tisdall, 52°14 W120°54	85	84	62	73
Beaver FR, 54°3 W122°10	75[b]	75[b]	11[b]	75[b]
Busk, 49°38 W117°9	63	24	7	0
Sharpe, 55°07 W127°21	56	12	0	4[b]
Alberni, 49°14 W124°44	52	12	6	0
Smallwood, 49°30 W117°26	40[c]	31	4	0

[a] Pooled sources: #1 MGR, #2 BC coast, #3 BC interior/Idaho/Montana, and #4 California/Warner Mts.
[b] Small sample size.
[c] After blister rust killed many young trees, drought appeared to preferentially kill the large survivors. In the MGR group this meant loss of canker-free trees and a reduction in the sample size to 30.

at Woss (northern Vancouver Island) was inspected in 2007. Washington sources at the other two plantations (Texada Island and southern Vancouver Island) were inspected in 2011 for rust status prior to scion collection. In each of these three plantations, the Washington source was least cankered at about 50 percent.

In BC, most cankers were located close to the ground (Hunt 1982, 1998) so the three demonstration plantations have largely grown through that young age when they were most susceptible to attack. To continue monitoring for the persistence of MGR resistance in BC, younger plantations should be inspected. More recently, the BC Forest Service has imported three seedlots from Dorena for operational use. We have periodically monitored one of these younger plantations and confirmed hypersensitive needle spots by inoculating offspring from canker-free parents. A 2013 survey of a 2002 trial using these three lots on three coastal sites, averaged 64, 66, and 70 percent canker-free trees per lot compared to 27, 29, and 30 percent canker-free trees for non-MGR selections. To date there is no evidence of MGR failure in BC.

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