Assessment of White Pine Blister Rust Resistant Plantings in Quetico Provincial Park: Summary Report

By Amy Adair

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Final Draft

Quetico Provincial Park acknowledges that the surveys summarized in this report were carried out on the traditional lands of the Anishinaabe people of Treaty Three.

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Executive Summary

White pine blister rust (*Cronartium ribicola*) is a pathogenic fungi that has caused significant losses of white pine throughout North America. In the early 1990s, over 4000 white pine seedlings that had been selected and bred for genetic resistance were planted in Quetico Provincial Park with the goal of enhancing natural regeneration of white pine. In 2016 and 2017 (23-26 years after planting) the majority of the planting sites (some could not be found) were revisited to assess the severity of blister rust infection. A control plot that was planted in the late 1990s/early 2000s, containing non-resistant white pine was also established and monitored for comparison purposes.

A total of 317 non-resistant trees (control) in 12 plots and 1034 resistant trees in 41 plots were surveyed. Health of the tree was determined by visually assessing the tree using a Vigour Class of 1-3 where 1 is a dead tree and 3 is a tree with no health problems. Level of blister rust infection was also determined using a visual assessment and was assigned a Severity Class of 1-4 where 1 is a tree that is dead from blister rust and 4 is a tree without blister rust.

Using simple Bayesian probabilities, it was found that trees in control plots had a 33.3% chance of dying due to blister rust infection while trees in resistant plots had a 16.4% chance of dying due to blister rust. The effect of free to grow status and the presence of *ribes* spp. was unclear. The observed rate of blister rust infection might also be influenced by stand age as the control plot was approximately 10 years younger than the resistant stands.

In future years, it is recommended that additional control plots are monitored to provide a more robust statistical comparison of blister rust infection between resistant and control trees. Controls plots, if possible, should more closely match the age and structure of the resistant plots monitored.

Table of Contents

Introduction

White Pine Blister Rust (*Cronartium ribicola)* is a pathogenic rust fungus that infects all five needle pine species, including white pine (*Pinus strobus)* in Ontario. WPBR spreads through two types of spores which infect pine and currant (*Ribes spp.*) species alternately. Fungal spores (basidiospores) are released from infected currant plants and germinate on pine needles or twigs in late summer. These spores grow into the tree's tissues, creating orange pustules and white oozing blisters on the bark. After a period of 3-6 years these lesions burst and release orange spores (aeciospores) which are carried by wind to infect currants, where the cycle begins again (See Figure 1) (Natural Resources Canada 2015; Government of Ontario 2016).

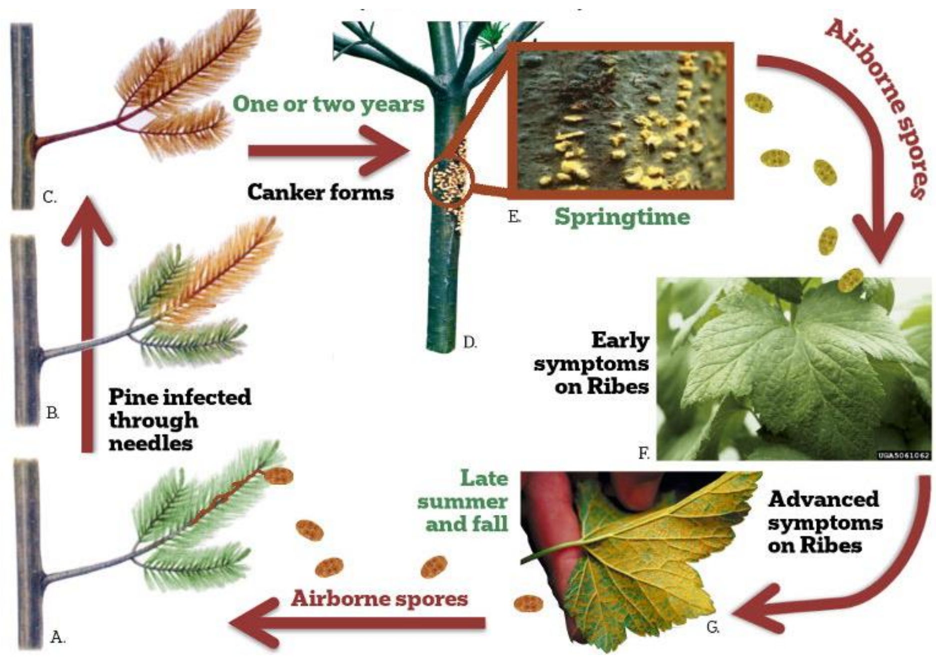

Figure 1: Simplified life-cycle of white pine blister rust. (American Public Gardens Association 2012) Photo Credit (from USDA Forest Service bugwood.org) A, B, C, D: Steven Katovich, E: USDA Forest Service, F: Joseph O'Brien, G: Robert L. Anderson

White Pine Blister Rust (WPBR) was introduced to North America in the early 1900s through imports of infected white pine nursery stock from Europe that was intended for replanting. Early infection rates were very high, with as much as 90% of the best trees lost in forests in the eastern United States (Van Arsdel 2011). WPBR impacts continue to be high in areas that are climatically favourable to the dispersal of spores, such as the cool, moist regions of northern Minnesota, Wisconsin, Michigan and north-central Ontario (Van Arsdel 2011).

White pine loss is of significant concern among foresters and recreationalists alike. Five needled pines and particularly white pine have a high commercial value due to their fast growth rate and lumber quality (Lu and Derbowka 2009). Furthermore, white pine is a valuable component of forest ecosystems and is an icon of Ontario's landscape (Lu and Derbowka 2009). In Quetico, visitors are drawn to the park by clear lakes surrounded by old growth pine forests (Ontario Parks 2017).

WPBR control efforts originally focused on eradication of currant species which proved difficult and costly due to their geographic spread, abundance and adaptability (Kinloch 2003). Genetic resistance, on the other hand, may provide a long term solution. In the 1960s, Cliff and Isabelle Ahlgren with the Quetico-Superior Wilderness Research Foundation, the USDA Forest Service, and the University of Minnesota, established a white pine plantation near Tofte, Minnesota. They planted 43176 white pine seedlings and after 11-13 years assessed the health, vigour and rate of infection of these trees. 888 trees (2.1% of the seedlings planted) were tagged as non-infected, which after a total of 40 years in the field made up 62.3% of the surviving trees. These selected trees are now the largest genetically diverse source of white pine trees with increased genetic resistance to WPBR in North America (David 2012).

In May of 1990, 1678 white pine seedlings from the Ahlgren's nursery were planted in 14 plots on Jean and Quetico Lake as well as in the Quetico Foundation Seed Orchard in Quetico Provincial Park. Plots were tended in 1991 and 1993 to reduce competition, and an additional 3089 seedlings were planted in 1992 (Pringle 1990; Pringle 1991; Pringle 1992; Pringle 1993). These plantings were a component of 'restorative management' intended to compliment forest succession and assist in preserving white pine stands in Quetico Park (Pringle 1989).

Following the early 1990s work, the white pine plots were left to mature and eventually almost forgotten. In 2005, Lila Sfilio, a masters student, visited four of the plots planted in 1990 and assessed the health of the stand and presence of WPBR. Between 9.1 and 56.3 % of each plot was found to be infected by blister rust though in some cases over 50% of the originally planted trees could not be found. In 2014 the MNRF Stewardship Youth Rangers surveyed six plots, including those visited by Sfilio. Of 600 trees originally planted in these plots, only 76 were found with 5.6% of these showing crown die off. The presence of WPBR does not appear to have been assessed.

To provide a more comprehensive evaluation of the health of Quetico's planted WPBR resistant white pine trees, in 2016 and 2017 the Quetico Foundation, in partnership with the Ministry of Natural Resources and Forestry, revisited the majority of the sites originally planted (see Table 1) as well as a control site (trees were not bred for genetic resistance). Champaigne-Klassen (2016) summarized the results from the Jean Lake plots, reporting an 18.8% probability that tree death in these plots was caused by blister rust. Allan (2017) compared results from the Seed Orchard to the control site. Though the resistant trees appeared to be slightly more healthy compared to the control, it was difficult to make a confident conclusion due to low sample size. This report will summarize the results of all surveys to date, using data from both Champaigne-Klassen's (2016) and Allan's (2017) reports as well as the most recent Quetico Lake surveys. See Appendix 2 for a full list of plot locations and work dates.

Table 1: WPBR work summary

Plot	Lake	# Trees Planted 1990	1992	Total % Survival 1993	Surveyed in *2005**	*2014**	2016	2017
M1	Quetico	50		52				Y
M2	Quetico	72		79				Y
M3	Quetico	35		86				Y
M4	Quetico	36		86				Y
D1	Jean	50	8	78				
D2	Jean	50	5	82			Y	
D3	Jean	50	1	90			Y	
D4	Jean	50	2	90			Y	
D5	Jean	100		95			Y	
D6	Jean	25		80			Y	
D7	Jean	50		92			Y	
D8	Jean	73		96			Y	
W1	Quetico River	50	160	40	*Y*	*Y*		Y
W2	Quetico River	25	154	76	*Y*	*Y*		Y
W3	Quetico	25		40		*Y*		Y
W4	Quetico	25		72		*Y*		
W5	Quetico	25		28		*Y*		Y
W6	Quetico	50		56	*Y*	*Y*		Y
W7	Cirrus	429		95				
W8	Quetico	155		98	*Y*			Y
W9	Cirrus	6		100				
W10	Beaverhouse	50		78				
FL	French Lake	5						
QFSO**	Stanton Bay	192	2300					
S1	*Stanton Bay*						Y	
S2	*Stanton Bay*						Y	
S3	*Stanton Bay*						Y	
S4	*Stanton Bay*						Y	
S5	*Stanton Bay*						Y	
S6	*Stanton Bay*						Y	
S7	*Stanton Bay*						Y	
S8	*Stanton Bay*						Y	
S9	*Stanton Bay*						Y	
S10	*Stanton Bay*						Y	
S11	*Stanton Bay*						Y	
S12	*Stanton Bay*						Y	
S13	*Stanton Bay*						Y	
S14	*Stanton Bay*						Y	
S15	*Stanton Bay*						Y	
S16	*Stanton Bay*						Y	
S17	*Stanton Bay*						Y	
S18	*Stanton Bay*						Y	
S19	*Stanton Bay*						Y	
S20	*Stanton Bay*						Y	
S21	*Stanton Bay*							
S22	*Stanton Bay*						Y	
S23	*Stanton Bay*						Y	
S24	*Stanton Bay*						Y	
S25	*Stanton Bay*						Y	

C4	Control 957			Y
C5	Control 957			Y
C13	Control 957			Y
C15	Control 957			Y
C19	Control 957			Y
C20	Control 957			Y
C21	Control 957			Y
C29	Control 957			Y
C37	Control 957			Y
C44	Control 957			Y
C45	Control 957			Y
C46	Control 957			Y

* Monitoring did not follow 2016 protocol described in text.
** Quetico Foundation Seed Orchard (also referred to as Gillnet Lake). The Stanton Bay Plantation plots were established here.

Objectives

1. Determine if planted genetically resistant white pine in Quetico Provincial Park are showing improved survival in the presence of white pine blister rust compared to unmanaged stands.

2. Assess the influence of environmental factors (including the presence of currant species and competition) on tree health.

Methods

Plot Locations – finding them

Plot locations were estimated from aerial photography as well as hand drawn maps and comments included in the initial planting reports (Pringle 1990; Pringle 1992). Crews were able to locate 7 plots on Jean Lake (D2-D8) and 10 plots on Quetico Lake (M1-M4 and W1, W2, W3, W5, W6, and W8). 25 plots (24 of which were surveyed) were also established in the Quetico Foundation Seed Orchard (more recently known as the Stanton Bay Plantation) where the majority of seedlings were planted. Finally, a control plot (51 plots, 12 of which were surveyed) was established in a white pine plantation near the Stanton Bay access road that contained non-resistant trees approximately 10 years younger than the resistant plots. The control plot was located in the same ecosite as the Stanton Bay plots however a similar-aged stand was not available to survey. Figure 2 contains a map of the plot locations and more detailed maps are available in Appendix 1.

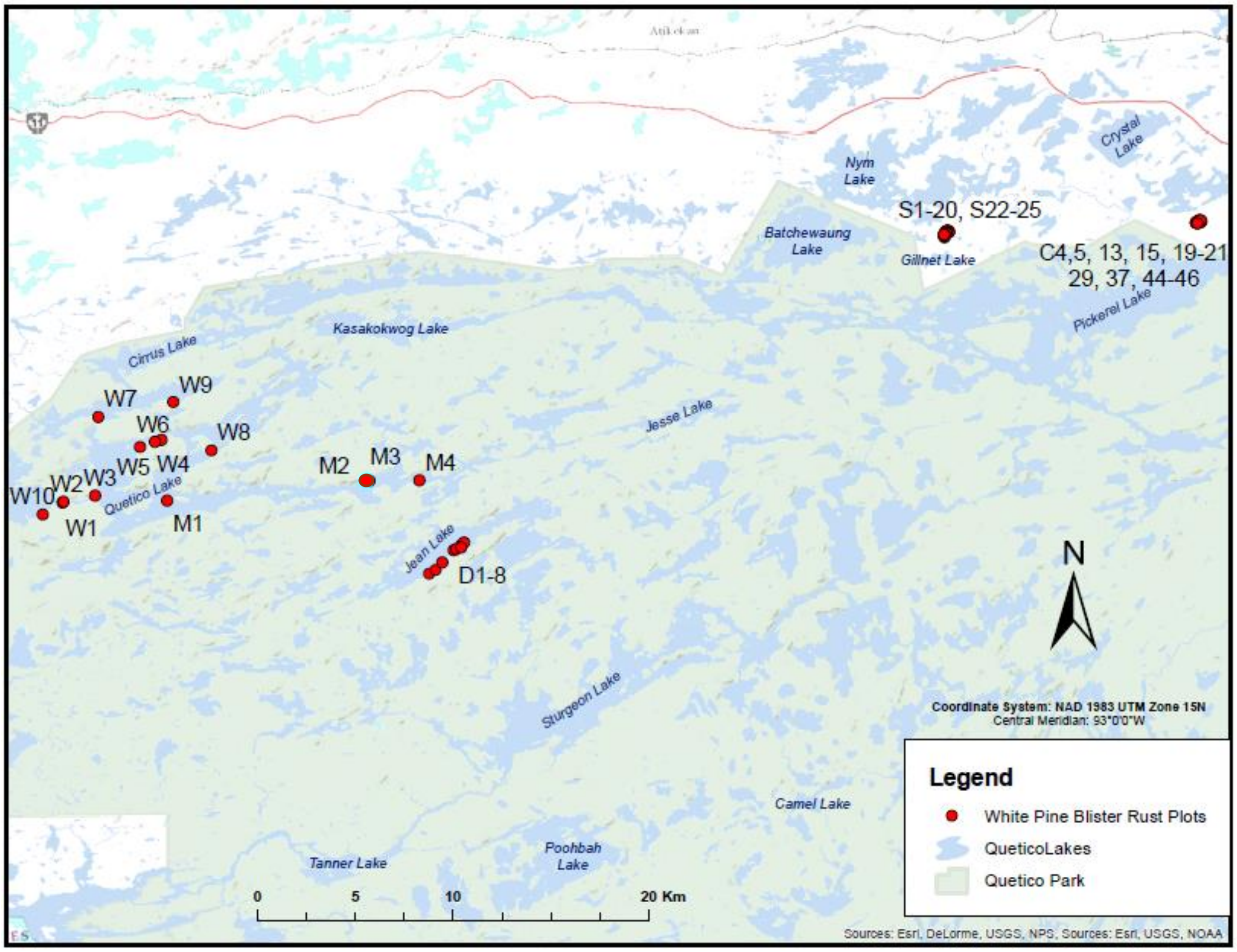

Figure 2: Location of the WPBR plots

Data Collection

Plots were monitored using the *White Pine Resistance Survey: Protocol* developed in 2016 by Renee Perry (MNRF Area Forester) and Bridget Antze (MNRF Technician). Plot locations were recorded with a waypoint and then marked with flagging tape using an 11.28 m (400 m^2 plots) plot cord and each tree within the plot was uniquely numbered. The site history, ecosite, soil type, veg-type, moisture regime, average height, average crown closure, average diameter, tree competition, and shrub competition for each plot was recorded. For each tree the diameter at breast height (DBH), well-spaced status, free-to-grow status, tree competition, shrub competition, vigour (see Table 3), severity of WPBR infection (see Table 2), health issues, and dimensions of the WPBR wound if present, was recorded.

2016_White Pine Resistance Survey.dc

Table 2: Blister rust infection severity ranked from 1 (most infected) to 4 (least infected). Adapted from David et al 2011.

Severity Class*	Description
1	- dead from blister rust
2	- active canker
3	- inactive canker
4	- no blister rust

Table 3: Tree health (vigour) ranked from 1 (least healthy) to 3 (most healthy).

Vigour Class	Description
1	- dead
2	- compromised health
3	- no apparent health issues

Statistical Analysis

Statistical analysis was performed in MS Excel, with a p-value of 0.05 was used as the cut-off for all determinations of statistical significance. Pairwise comparisons between number of dead and infected trees per plot , number of trees that were free to grow per plot, and tree diameter in control compared to resistant plots were made using a two-sample t-test for populations with equal variance if equality of variance was verified using an f-test statistic. Otherwise a t-test assuming unequal variance was used. Cohen's effect size, a measure of the strength of the interaction was also determined for each pairwise comparison. Simple Bayesian statistics, which is based on conditional probabilities, was also used to determine the probability of tree death caused by blister rust. A data summary is available in Appendix 3.

Results

Plot Characteristics

During 2016 and 2017, 317 non-resistant trees (control) in 12 plots and 1034 resistant trees in 41 plots were surveyed (Figure 3). No significant difference ($p = 0.779$, $d = 0.081$) was found between the average number of trees per plot in control (26.4 trees) compared to resistant (25.2 trees) plots. Average diameter of trees in control plots (4.5 cm) was significantly ($p = 8.12E-73$, $d = 1.28$) lower than the average tree diameter in resistant plots (11.6 cm) though note that the effect size between this comparison is high. The size distributions of tree diameter (Figure 4) illustrate this trend, with the majority of trees in control plots in the 0-6cm diameter classes and trees in the resistant plots showing a more even size distribution.

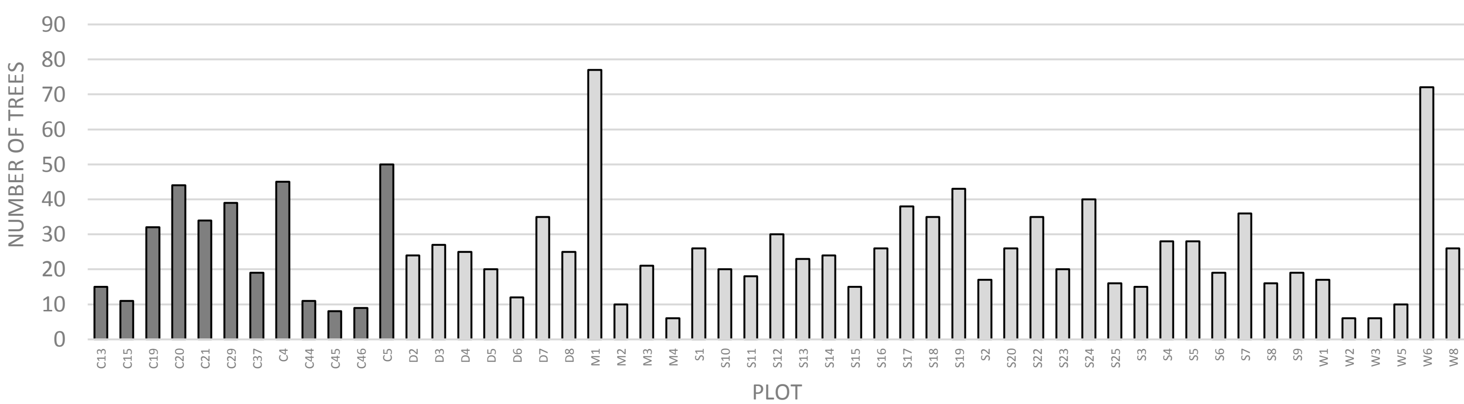

Figure 3: Number of trees per plot for all plots (control and resistant)

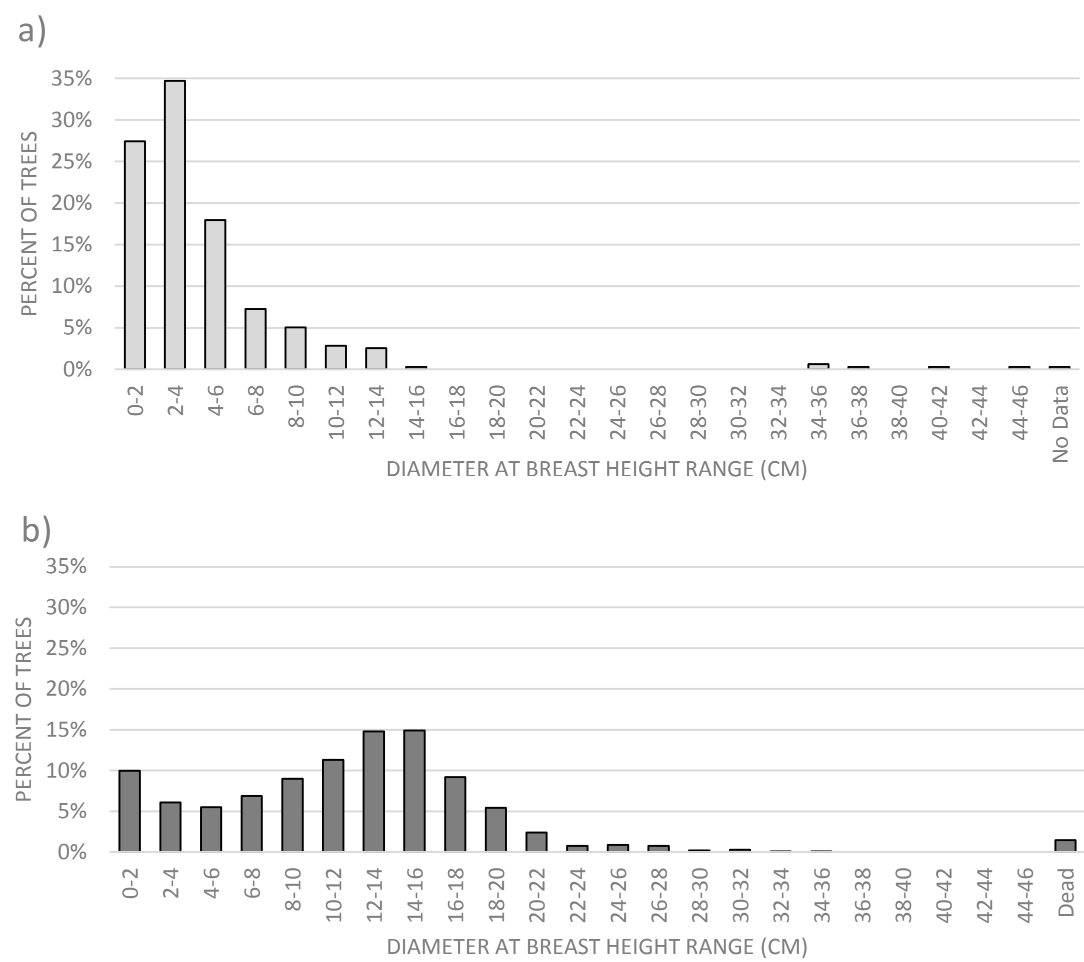

Figure 4: Size histogram of trees in a) control plots and b) resistant plots. Note that many seedlings (< 1m tall) and dead trees in the resistant plots did not have a diameter recorded. Dead trees were separated and seedlings were all included as having diameter 0-2 cm.

WPBR Infection

T-tests between the number of dead trees per plot and the number of trees infected by blister rust per plot between control and resistant plots did not return significant results (Table 4). The majority of trees in both plots were healthy and were not infected with WPBR (Figure 5 and 6). However, using Baye's theorem (Table 5 and Equation 1), which accounts for conditional probabilities, control plots were found to have a 33.3% probability of tree death caused by blister rust while resistant plots had a 16.4% probability of tree death caused by blister rust.

Table 4: comparison of the number of dead trees and the number of WPBR infected trees per plot. Values in brackets are averages, values in square brackets are the Cohen's effect size.

Dead Trees per plot	Control	Resistant
Control (1.5)	-	
Resistant (1.8)	0.622[0.176]	-

Infected Trees per plot	Control	Resistant
Control (3.25)	-	
Resistant (2.02)	0.127[0.530]	-

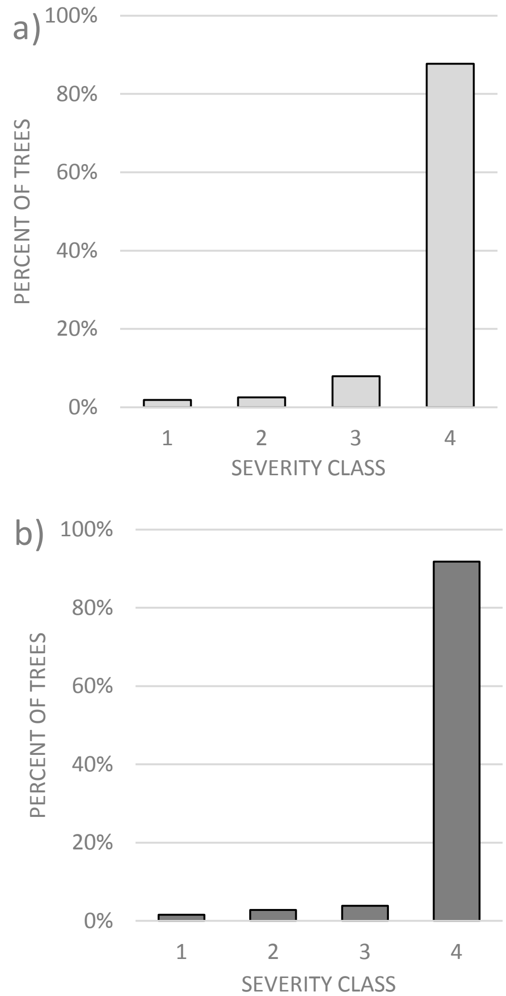

Figure 5: The number of trees in each Severity Class for a) control plots and b) resistant plots.

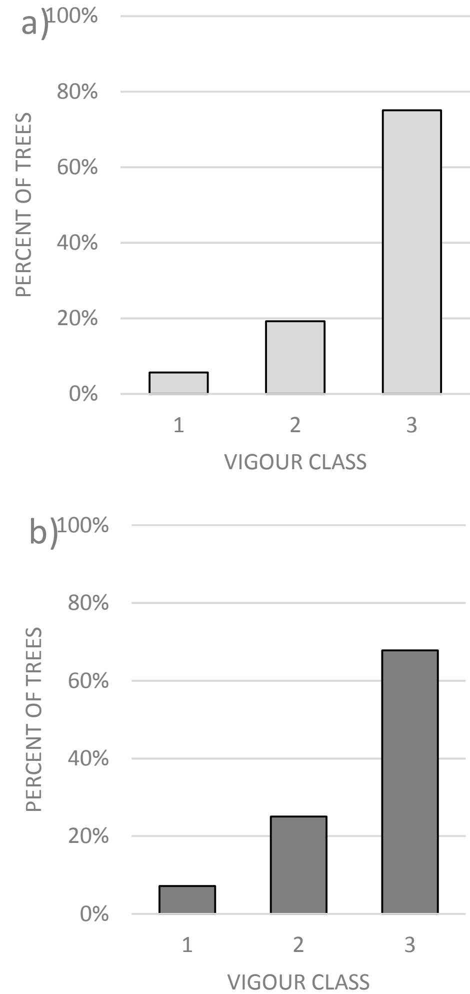

Figure 6: The number of trees in each Vigour Class for a) control plots and b) resistant plots.

Table 5: comparison of tree numbers on control and resistant plots

Number of	Control	Resistant Plots
Trees	317	1034
Dead Trees	18	74
Trees with Blister Rust	39	85
Trees Dead from Blister Rust	6	16

a) Control Plots

$$P(A|B) = p(B|A) * \frac{p(A)}{p(B)}$$

$$P(dead\ tree|blister\ rust) = p(BR|dead) * \frac{p(dead)}{p(BR)}$$

$$= \frac{6}{18} * \left[\left(\frac{18}{317}\right) / \left(\frac{39}{317}\right)\right]$$

$$= 0.333$$

$$= 33.3\%$$

b) Resistant Plots

$$P(A|B) = p(B|A) * \frac{p(A)}{p(B)}$$

$$P(dead\ tree|blister\ rust) = p(BR|dead) * \frac{p(dead)}{p(BR)}$$

$$= \frac{16}{85} * \left[\left(\frac{74}{1034}\right) / \left(\frac{85}{1034}\right)\right]$$

$$= 0.164$$

$$= 16.4\%$$

Equation 1: applying Baye's theorem to the data presented in Table 3 for a) control plots and b) resistant plots

In control plots, all trees that were dead from blister rust (Severity Class 1) or had active cankers (Severity Class 2) had a diameter < 10cm. Resistant plots on the other hand have a large size distribution within all severity classes (Figure 7).

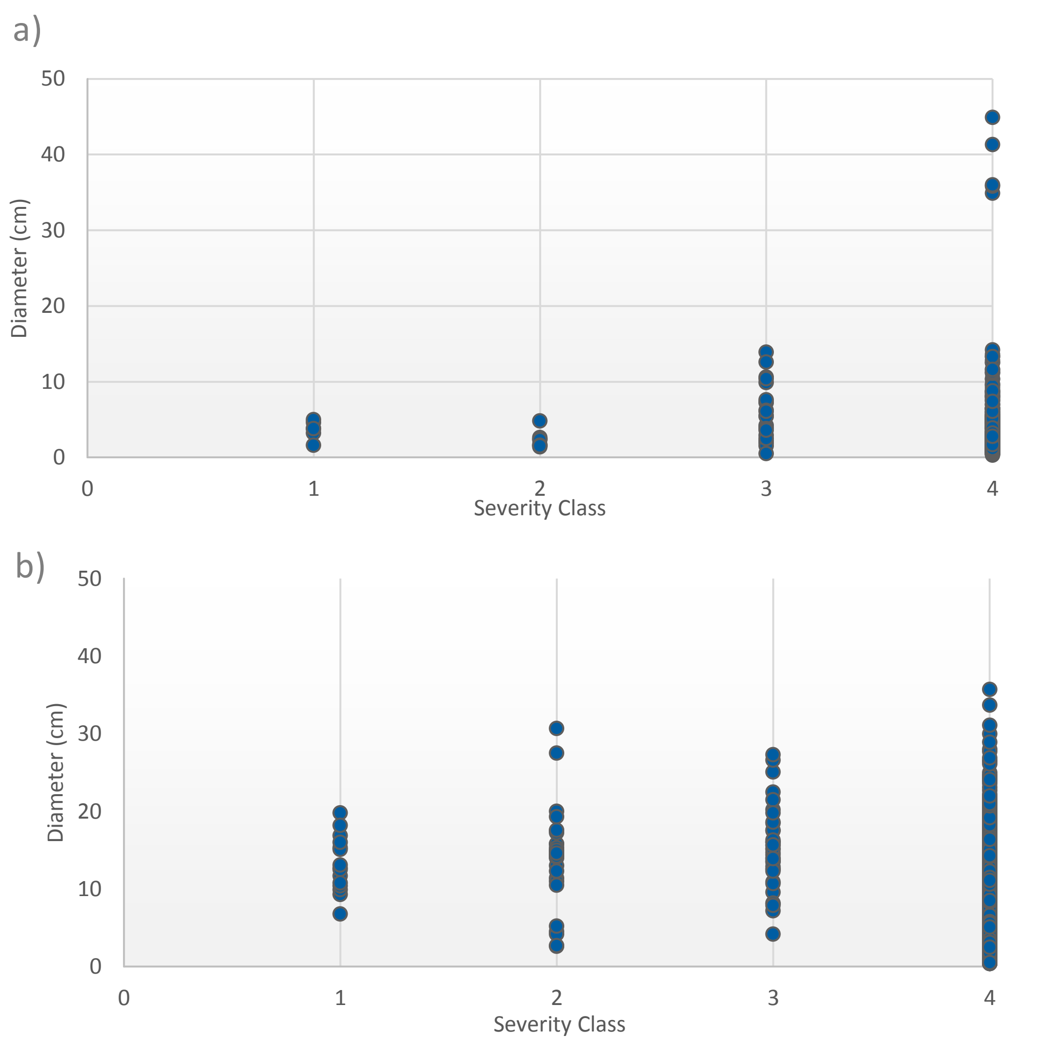

Figure 7: The diameter of trees in each Severity Class for a) control plots and b) resistant plots.

Competition

Control plots (mean = 6.2 trees per plot) had significantly (p = 0.009, d = 1.00) fewer trees per plot that were free to grow compared to resistant plots (mean = 13.1 trees per plot) (Figures 8). The number of trees that were well spaced per plot was not significantly different (Figures 9). Due to the difference in FTG status between control and resistant plots, the number of trees infected by WPBR that were free to grow was also compared. An average of 0.6 infected trees that were free to grow were found in control plots. This was not significantly different from the average of 1.3 infected, free to grow trees found in resistant plots.

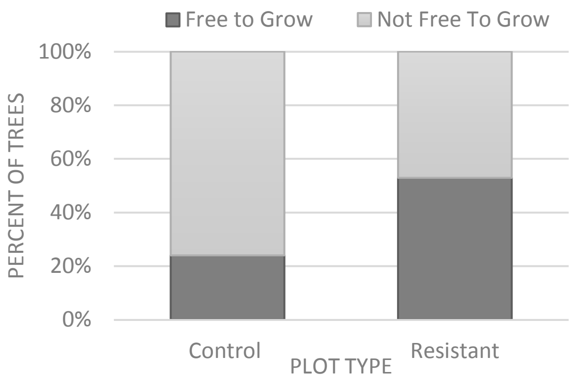

Figure 8: Percent of trees that are free to grow in control and resistant plots

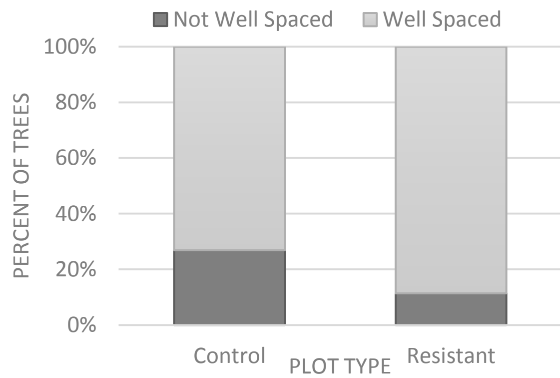

Figure 9: Percent of trees that are well spaced in control and resistant plots

The relationship between Severity Class and Diameter was not significant (Figure 10).

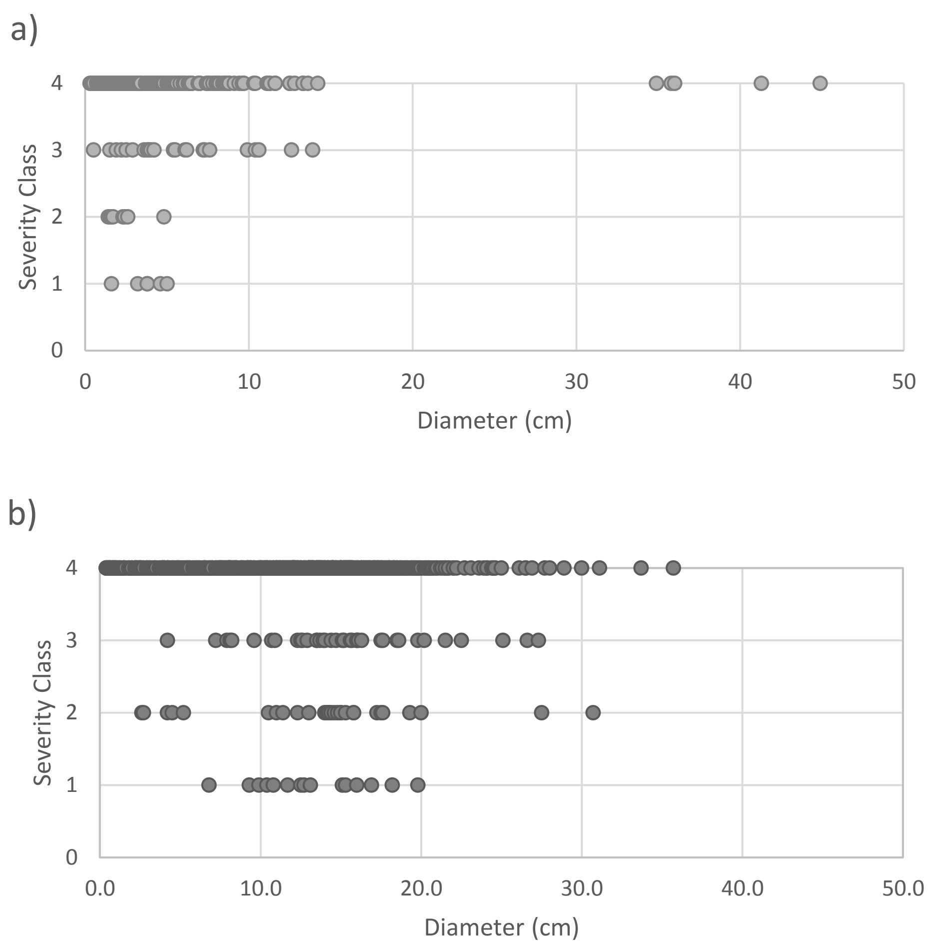

Figure 10: Severity class vs diameter at breast height (cm) for a) control plots and b) resistant plots.

Discussion

Stand size distribution and structure varied between control and resistant plots. This is most likely due to overall stand age. The majority of white pine planting in north-western Ontario began in the mid-1990s (Perry, pers. com. November 2017), after Pringle and colleagues planted the resistant stands in Quetico. This made it difficult to establish control plots that were the same age as the resistant plots. Therefore, the majority of trees in the control plots are young seedlings and saplings, with a few very large overstory trees. Resistant plots on the other hand show an older, even-age distribution as a result of planting; the majority of trees are between 10 and 18 cm DBH.

The difference in age structure may influence the observed rate of WPBR infection. First of all, early monitoring of planted trees showed that many seedlings were lost in the first couple years after planting (Pringle 1993). If this trend continued, it is quite likely that the young saplings that died (naturally or from blister rust) were not present to be recorded during the 2016 and 2017 resistant plot studies. In the control plot on the other hand, saplings are still present. Furthermore, if WPBR infects young white pine trees more frequently than older trees, the loss of saplings in resistant plots would further skew the results. Results from this study do not show a relationship between tree size and the severity of blister rust infection, however there is some evidence to support the theory that pine trees become more resistant to WPBR over time. Patton (1961) found that four year old white pine seedlings had a lower infection rate compared to year-old seedlings. Furthermore, grafts from 10, 20, 40 and 80 year old trees were infected at progressively lower rates as the age of the graft increased. In the closely related western white pine, Hunt (2005) also found that cankers developed earlier on seedlings than on scions from resistant parent trees (mean age of the parent tree was 49 years). However, though WPBR can infect trees at any age, it is not known if there is an age at which WPBR infection peaks, or at which trees are most effective at preventing infection.

It is difficult to determine if competition is influencing the rate of WPBR infection. More trees were free to grow in resistant plots, and no significant difference in the number of trees infected between control and resistant plots was observed when free to grow status was controlled for. However, only 7 trees in control plots were free to grow and infected by WPBR. This low sample size makes it difficult to make a reliable comparison.

Ribes eradication is a common method of controlling WPBR infection (Van Arsdel 1961). In Quetico, only 2 trees in the control plots and 9 trees in the resistant plots had *ribes* spp. present within a 1.2m radius of the tree. Therefore, it is difficult to determine if the presence of *ribes* spp. influences tree health in these plots. However, the prevalence of WPBR despite low densities of *ribes* spp. is consistent with the ability of WPBR spores to be dispersed long distances on the wind (Natural Resources Canada 2015; Government of Ontario 2016).

Future Research

1) Monitor additional control plots

Due to the low sample size of non-resistant trees, it is difficult to draw reliable conclusions from the existing data. Plans are in place to monitor additional control plots during the summer of 2018. If possible, additional control plots should more closely reflect the size structure of the resistant plots.

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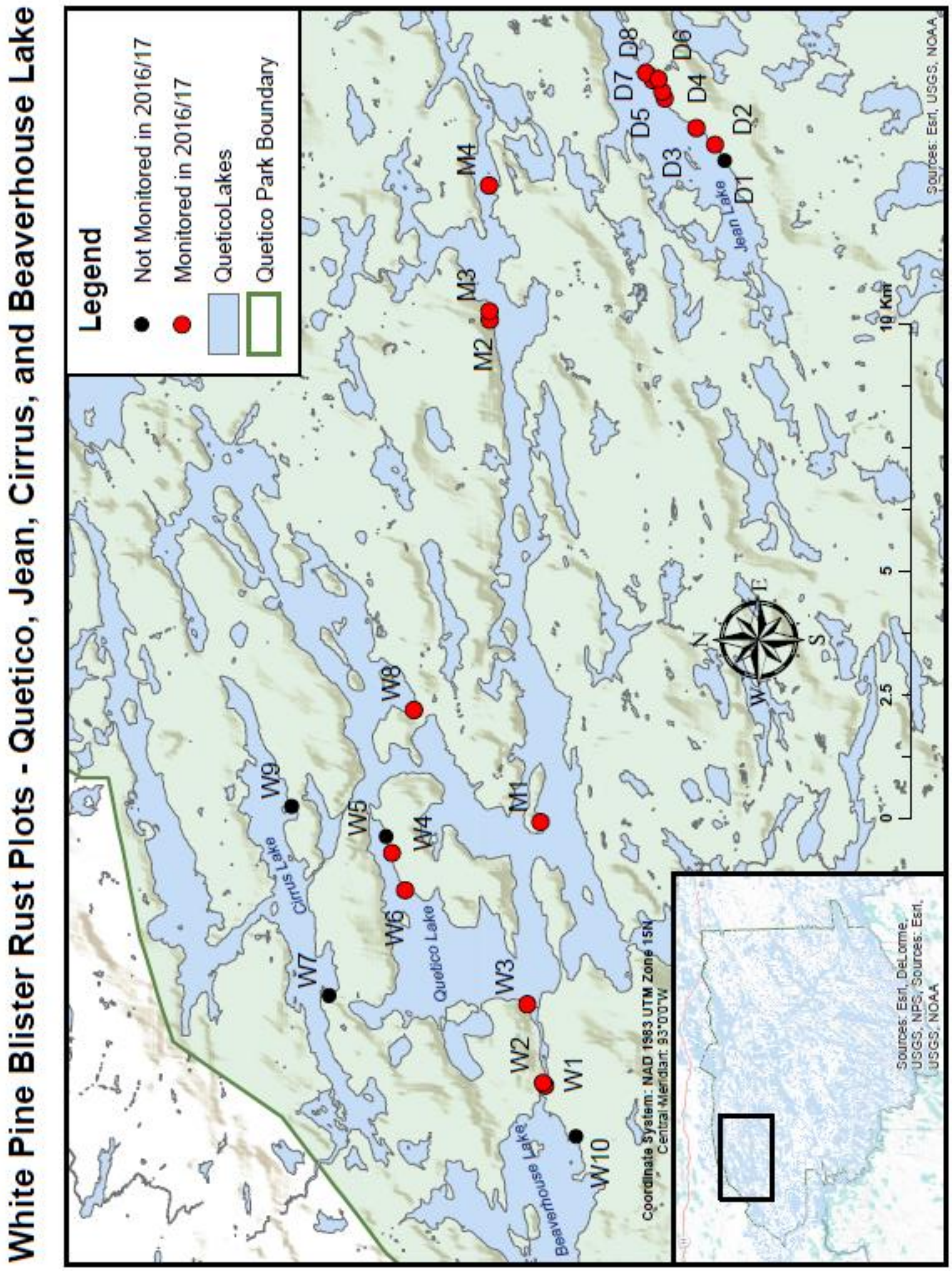
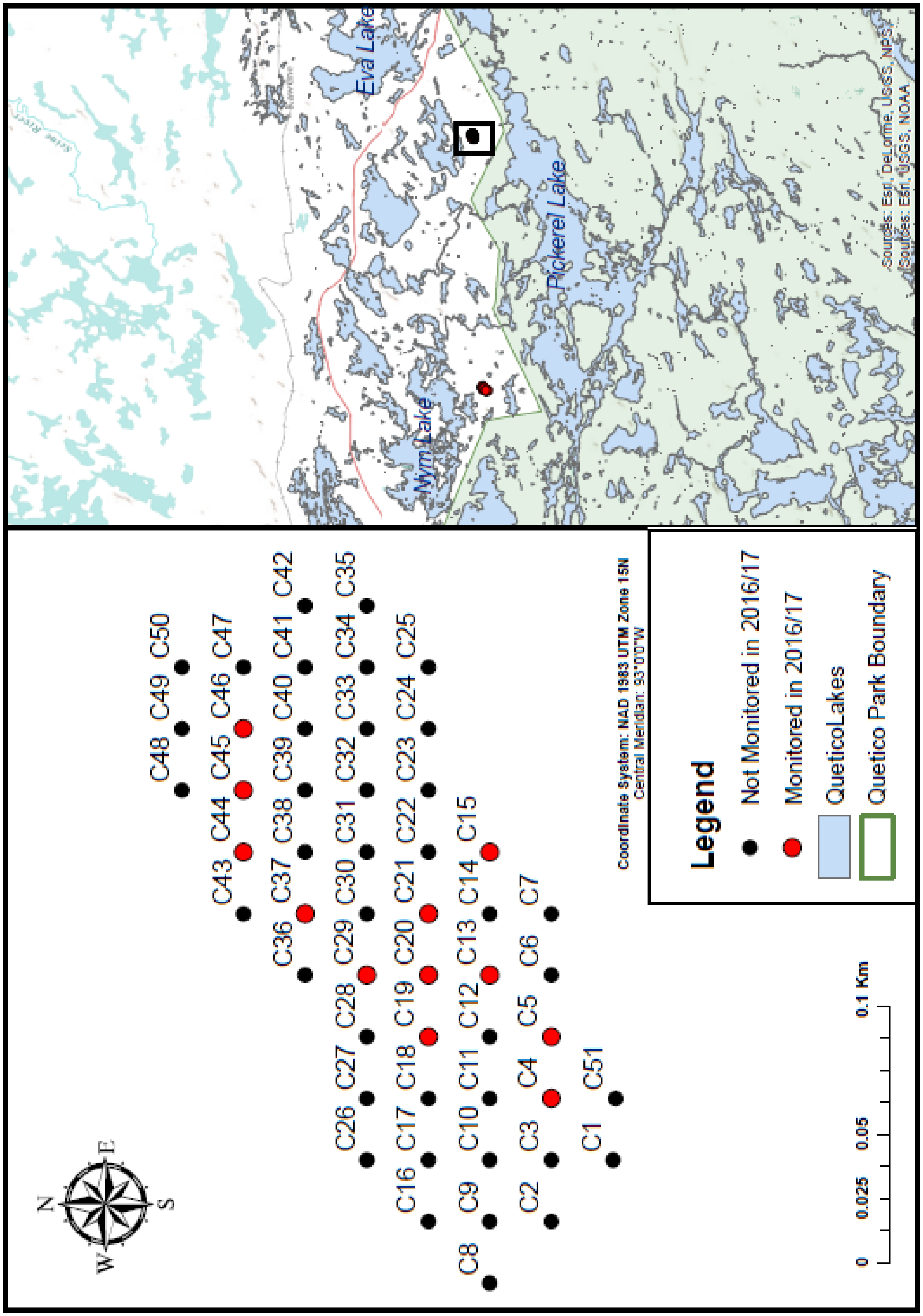
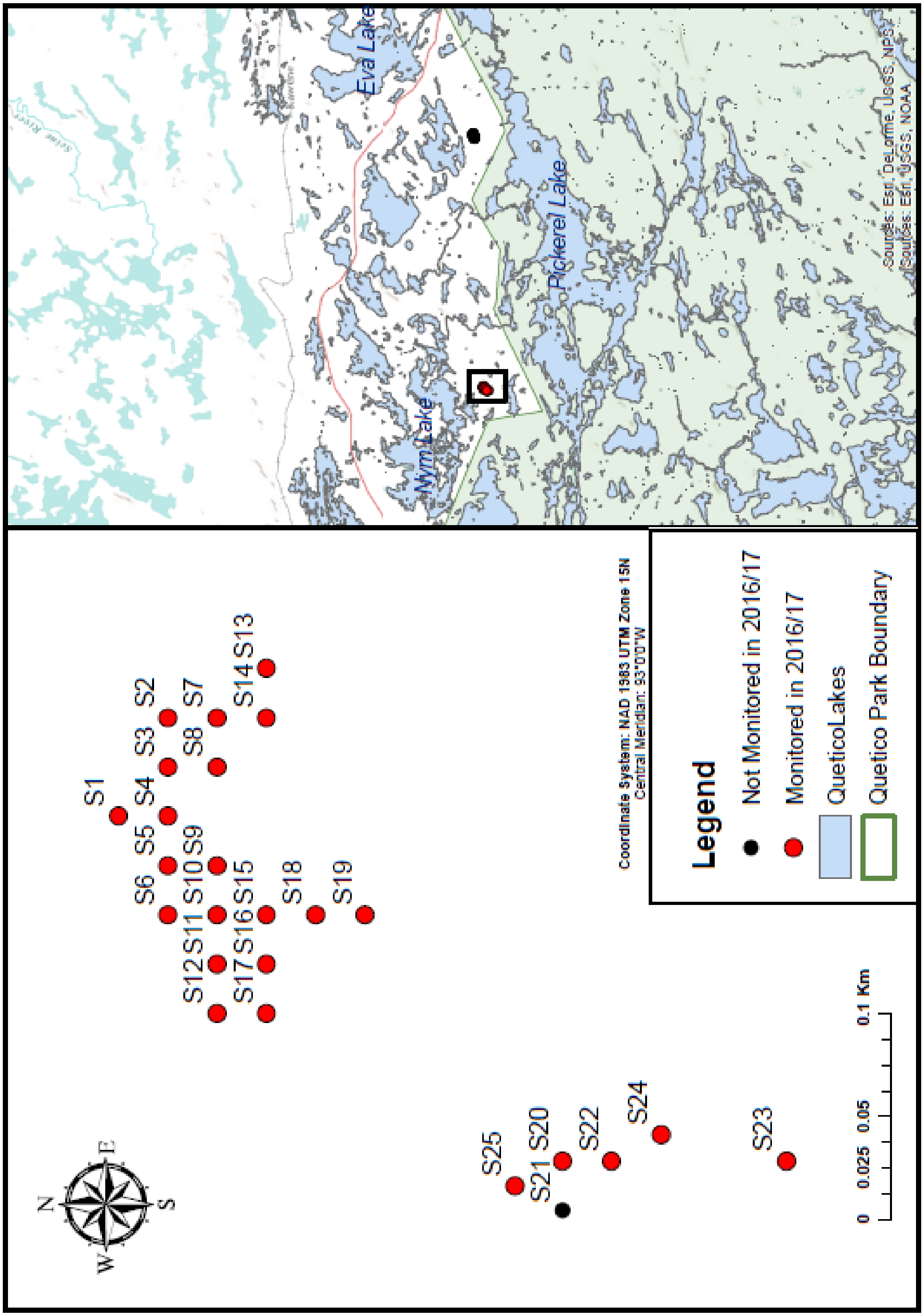
Appendix 1. Plot Locations



White Pine Blister Rust Plots - Control



White Pine Blister Rust Plots - Stanton Seed Orchard



Appendix 2. White Pine Blister Rust Monitoring History

				# Trees Planted		Total % Survival	Surveyed in			
Plot	**Lake**	**Easting**	**Northing**	**1990**	**1992**	**1993**	**2005**	**2014**	**2016**	**2017**
M1	Quetico	577335	5377885	50		52				Y
M2	Quetico	587488	5378903	72		79				Y
M3	Quetico	587660	5378913	35		86				Y
M4	Quetico	590200	5378926	36		86				Y
D1	Jean	590714	5374160	50	8	78				
D2	Jean	591031	5374354	50	5	82			Y	
D3	Jean	591367	5374732	50	1	90			Y	
D4	Jean	591961	5375368	50	2	90			Y	
D5	Jean	592337	5375611	100		95			Y	
D6	Jean	592099	5375416	25		80			Y	
D7	Jean	592485	5375745	50		92			Y	
D8	Jean	592353	5375497	73		96			Y	
W1	Quetico River	572003	5377792	50	160	40	Y	Y		Y
W2	Quetico River	572063	5377834	25	154	76	Y	Y		Y
W3	Quetico	573645	5378141	25		40		Y		Y
W4	Quetico	577035	5380997	25		72		Y		
W5	Quetico	576706	5380883	25		28		Y		Y
W6	Quetico	575956	5380620	50		56	Y	Y		Y
W7	Cirrus	573819	5382153	429		95				
W8	Quetico	579593	5380441	155		98	Y			Y
W9	Cirrus	577650	5382915	6		100				
W10	Beaverhouse	570980	5377166	50		78				
FL	French Lake			5						
QFSO*	Gillnet Lake			192	2300					
S1	*Stanton Bay*	*617157*	*5391656*						Y	
S2	*Stanton Bay*	*617205*	*5391632*						Y	
S3	*Stanton Bay*	*617181*	*5391632*						Y	
S4	*Stanton Bay*	*617157*	*5391632*						Y	
S5	*Stanton Bay*	*617133*	*5391632*						Y	
S6	*Stanton Bay*	*617109*	*5391632*						Y	
S7	*Stanton Bay*	*617205*	*5391608*						Y	
S8	*Stanton Bay*	*617181*	*5391608*						Y	
S9	*Stanton Bay*	*617133*	*5391608*						Y	
S10	*Stanton Bay*	*617109*	*5391608*						Y	
S11	*Stanton Bay*	*617085*	*5391608*						Y	
S12	*Stanton Bay*	*617061*	*5391608*						Y	
S13	*Stanton Bay*	*617229*	*5391584*						Y	
S14	*Stanton Bay*	*617205*	*5391584*						Y	
S15	*Stanton Bay*	*617109*	*5391584*						Y	
S16	*Stanton Bay*	*617085*	*5391584*						Y	
S17	*Stanton Bay*	*617061*	*5391584*						Y	
S18	*Stanton Bay*	*617109*	*5391560*						Y	
S19	*Stanton Bay*	*617109*	*5391536*						Y	
S20	*Stanton Bay*	*616989*	*5391440*						Y	
S21	*Stanton Bay*	*616965*	*5391440*							
S22	*Stanton Bay*	*616989*	*5391416*						Y	
S23	*Stanton Bay*	*616989*	*5391331*						Y	
S24	*Stanton Bay*	*617002*	*5391392*						Y	
S25	*Stanton Bay*	*616977*	*5391463*						Y	
C1	Control 957	629880	5392022							
C2	Control 957	629856	5392046							
C3	Control 957	629880	5392046							
C4	Control 957	629904	5392046							Y
C5	Control 957	629928	5392046							Y
C6	Control 957	629952	5392046							

C7	Control 957	629976	5392046		
C8	Control 957	629832	5392070		
C9	Control 957	629856	5392070		
C10	Control 957	629880	5392070		
C11	Control 957	629904	5392070		
C12	Control 957	629928	5392070		
C13	Control 957	629952	5392070		Y
C14	Control 957	629976	5392070		
C15	Control 957	630000	5392070		Y
C16	Control 957	629856	5392094		
C17	Control 957	629880	5392094		
C18	Control 957	629904	5392094		
C19	Control 957	629928	5392094		Y
C20	Control 957	629952	5392094		Y
C21	Control 957	629976	5392094		Y
C22	Control 957	630000	5392094		
C23	Control 957	630024	5392094		
C24	Control 957	630048	5392094		
C25	Control 957	630072	5392094		
C26	Control 957	629880	5392118		
C27	Control 957	629904	5392118		
C28	Control 957	629928	5392118		
C29	Control 957	629952	5392118		Y
C30	Control 957	629976	5392118		
C31	Control 957	630000	5392118		
C32	Control 957	630024	5392118		
C33	Control 957	630048	5392118		
C34	Control 957	630072	5392118		
C35	Control 957	630096	5392118		
C36	Control 957	629952	5392142		
C37	Control 957	629976	5392142		Y
C38	Control 957	630000	5392142		
C39	Control 957	630024	5392142		
C40	Control 957	630048	5392142		
C41	Control 957	630072	5392142		
C42	Control 957	630096	5392142		
C43	Control 957	629976	5392166		
C44	Control 957	630000	5392166		Y
C45	Control 957	630024	5392166		Y
C46	Control 957	630048	5392166		Y
C47	Control 957	630072	5392166		
C48	Control 957	630024	5392190		
C49	Control 957	630048	5392190		
C50	Control 957	630072	5392190		
C51	Control 957	629904	5392021		

* Quetico Foundation Seed Orchard (also referred to as Gillnet Lake). The Stanton Bay Plantation plots were established here.

Appendix 3. White Pine Blister Rust Monitoring Data Summary

Plot	Number of Trees	Average Diameter (cm)	Count of Vigour 1	2	3	Count of Severity 1	2	3	4
C4	45	4.5	1	9	35		3	2	40
C5	50	3.5	1	6	43		2	4	44
C13	15	5.1	1		14	1			14
C15	11	4.5	1	4	6	1	1	2	7
C19	32	3.4	1	3	28				32
C20	44	2.3	4	7	33		1	2	41
C21	34	6.1		5	29		1	1	32
C29	39	5.5	5	8	26	1		6	32
C37	19	4.9	1	10	8	1		3	15
C44	11	6.3	1	5	5	1		3	7
C45	8	8.3	1	3	4			2	6
C46	9	5.9	1	1	7	1			8
S1	26	164.0	4	10	51		1		25
S2	17	71.4	1	8	36		1		16
S3	15	144.5	3	10	21				15
S4	28	15.9		16	60		3		25
S5	28	82.6	5	12	51		2	4	22
S6	19	115.2	1	8	42	1		2	16
S7	36	14.7	2	4	96				36
S8	16	13.8	3	10	24		1	2	13
S9	19	14.4	2		51				19
S10	20	12.0		4	54				20
S11	18	12.5	1	8	39			2	16
S12	30	12.7	3	12	63	2	1	1	26
S13	23	13.5		18	42		2	1	20
S14	24	88.0	5	12	45	2		3	21
S15	15	15.5	4		33				15
S16	26	12.5		16	54		1	1	24
S17	38	63.7	2	14	87			6	32
S18	35	15.1	1	26	63			1	34
S19	43	13.0	4	10	102				43
S20	26	10.2	2	6	63			1	25
S22	35	13.5	3	6	87				35
S23	20	11.2	2	10	39				20
S24	40	13.9		18	93		2	3	35
S25	16	11.3	1		45				16
D2	24	13.4	7	10	36	1	2	1	20
D3	27	8.7	2		75				27
D4	25	12.6	1	12	54			3	22
D5	20	11.5		6	51		1	1	18
D6	12	12.2		10	21		1	1	10
D7	35	9.6	1	4	96	1	2		32
D8	25	12.4	1	24	36				25
M1	77	2.7	3	90	87		3	1	73
M2	10	14.5	1	10	12	1	1	1	7
M3	21	7.9		16	39		1		20
M4	6	0.8		6	9				6
W1	17	24.8		4	45			1	16
W2	6	11.1	1	10		1		1	4
W3	6	11.5		10	3				6
W5	10	1.6		4	24				10
W6	72	1.7		42	153		1		71
W8	26	18.6	8	22	21	7	3	3	13