Efficacy of Early Pruning to Reduce the Incidence of White Pine Blister Rust on Sugar Pine (*Pinus lambertiana*)

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INTRODUCTION

Sugar pine (*Pinus lambertiana*) is a five-needle pine native to the mixed-conifer forests of the Sierra Nevada and Cascade Ranges of western North America. Sugar pine has great aesthetic, ecological, and economic value and is among the largest of all pines. Like other five-needle pines, sugar pine is susceptible to white pine blister rust (WPBR), caused by the nonnative pathogen *Cronartium ribicola*. Although tree-breeding efforts have been the most successful strategy against WPBR, artificial pruning by removing the lowest branches (where infections are most common) can potentially enhance survival of five-needle pines exposed to WPBR. Artificial pruning has been used successfully in WPBR management programs for western white pine (*Pinus monticola*), although most pruning is not done until trees are 10- to 15-year-old saplings. Earlier pruning against WPBR cankers and pruning on sugar pine have received less attention. As part of a larger restoration effort involving several Federal agencies, personnel from the U.S. Department of Agriculture, Forest Service, Dorena Genetic Resource Center (DGRC; Cottage Grove, Oregon, USA) established monitoring plots to measure the efficacy of early pruning on the incidence and impact of WPBR on planted sugar pine seedlings.

METHODS

Ten planting sites with moderate-to-high WPBR pressure were selected in the southern Cascade Range of Oregon, near the Little River on the Umpqua National Forest. For each site, sixteen 202-m^2 plots were established, cleared of woody vegetation, and planted with improved and unimproved sugar pine seedlings. Twenty-four families of containerized seedlings were grown at the DGRC and outplanted in fall 2000. These families comprised eight resistant families (SB orchard), eight F1 orchard families, and eight demonstrated nonresistant families (Wild). Each plot was planted with the same mix of 24 seedlings, one representative per family per plot.

Using a paired plot design, half of the plots at each site were randomly selected for the pruning treatment, and the other half remained untreated as controls. All trees in the treated plots were pruned following the fourth growing season (2003, when they were 1.2 to 1.5 m in height) and every 4 years thereafter. Whole branches were removed, starting at the ground, leaving about 50 percent canopy remaining. Periodic pruning will continue until the trees are pruned to a height of 3 m. Surveys began in the fall of the fourth year and continued every 2 to 4 years through 2012. Data collected

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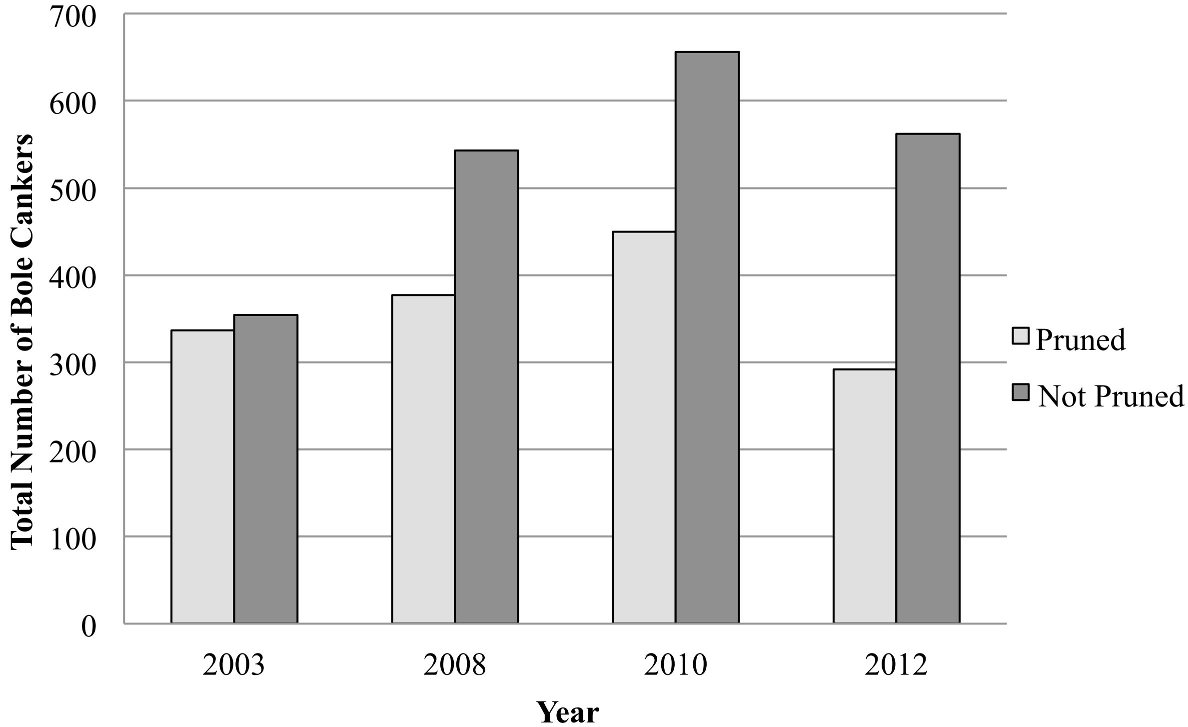

Figure 1—The total number of bole cankers on live trees for each year recorded.

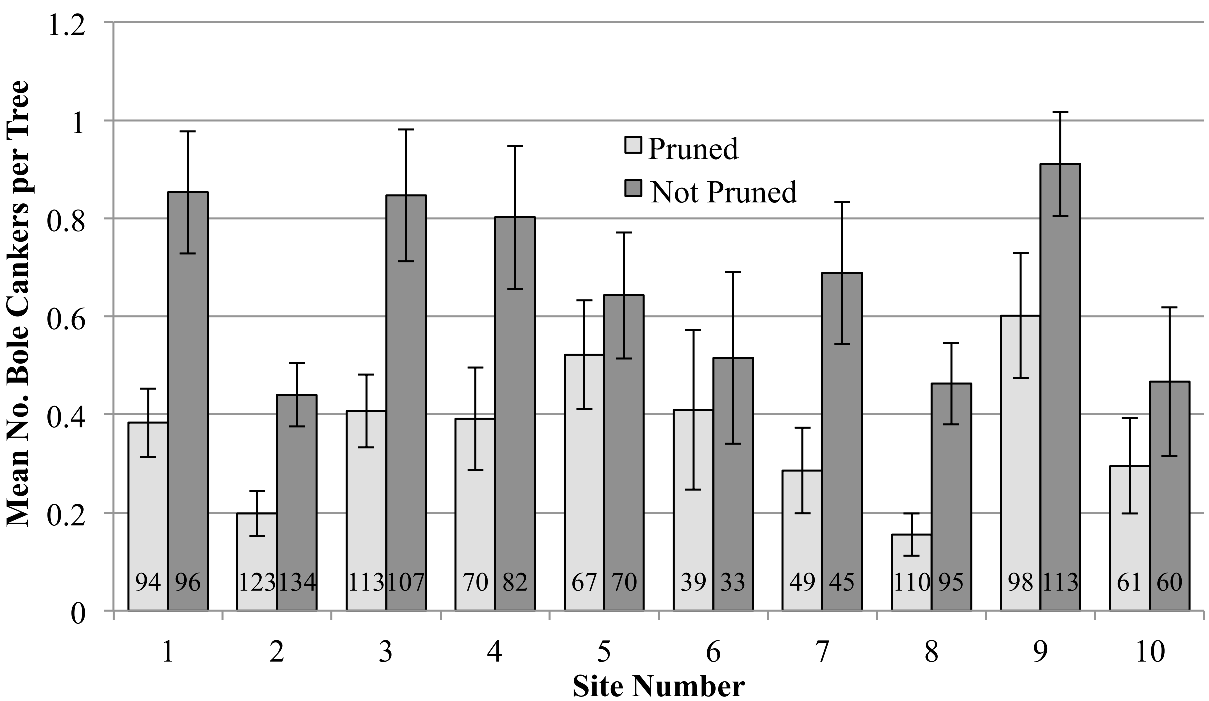

Figure 2—The mean number of bole cankers on live trees per site in 2012. Error bars indicate ± standard error of the mean. Numbers inside bars indicate the total number of live trees on the site indicated.

during the surveys include: mortality (and cause if evident), number and location of branch cankers, number and location of bole cankers, percentage of the bole circumference girdled by cankers, and other comments. The number of branch cankers on trees in treatment plots was recorded prior to pruning.

RESULTS AND DISCUSSION

Cumulative percent mortality on all sites was surprisingly similar between pruned and unpruned plots for the years recorded; in fact, cumulative mortality in 2012 was identical, 55 percent, for pruned and unpruned plots. Similarly, the percentage of trees that were killed by WPBR differed little between pruned and unpruned plots; 57 and 59 percent of mortality, respectively, was attributed to WPBR. WPBR was the primary mortality agent although all of the plots contained trees that suffered from animal and insect damage as well. The average height of trees in 2012 was 3.1 m on pruned plots, and 3.4 m on unpruned plots. Height growth of trees was highly variable within and between plots, but appeared to be minimally affected by early pruning. Between 2004 and 2012, the average increase in height of trees was 1.9 m (±0.9 m SD) on the pruned plots and 2.3 m (±1.1 m SD) on unpruned plots.

Overall, more total cankers were observed on untreated, control plot trees than on treated, pruned plot trees. As of 2012, trees in unpruned plots contained almost three times as many branch cankers as the pruned plots (2,147 and 785, respectively). This result is confounded by the pruning treatment that removes lower branches and reduces potential infection area. Analysis accounting for this reduction in lower branches and resistance capacity may reveal more subtle differences between treatment, family resistance, or both.

The most promising result thus far has been the reduction of bole (stem) cankers on trees in pruned plots. As of 2012, there were 292 bole cankers on trees on the pruned plots, compared to 562 bole cankers on unpruned plots (fig. 1). Trees on the pruned plots have had lower numbers of bole cankers consistently throughout the study (table 1). The average number of bole cankers recorded per tree has also been substantially less on pruned plots (fig. 2). In addition, pruning appears to reduce the percentage of trees with bole cankers regardless of seedling type (fig. 3). As of 2012, 16 percent of the F1 orchard families on pruned plots had bole cankers, compared to 31 percent on unpruned plots. Although early pruning has not yet resulted in a significant reduction in WPBR-caused mortality, the lower number of bole cankers on these trees is very promising. It is likely that we will not see the full benefits of pruning for several more years. Surveys are expected to continue through 2020.

Table 1—Total number of bole cankers in each site according to treatment[a] and year.

Site No.	2003		2008		2010		2012	
	P	NP	P	NP	P	NP	P	NP
1	14	12	54	66	67	99	36	81
2	12	8	17	44	27	73	24	59
3	6	8	42	94	33	98	47	90
4	21	38	35	40	23	37	27	65
5	31	62	33	62	40	63	35	45
6	152	142	48	49	36	64	16	17
7	60	53	59	78	76	74	14	31
8	3	6	5	22	7	32	17	44
9	7	14	53	60	108	92	59	102
10	31	13	31	28	33	24	18	28
Mean	34	36	38	54	45	66	29	56

[a] P - Pruned (treated) plots. NP – Unpruned (control) plots

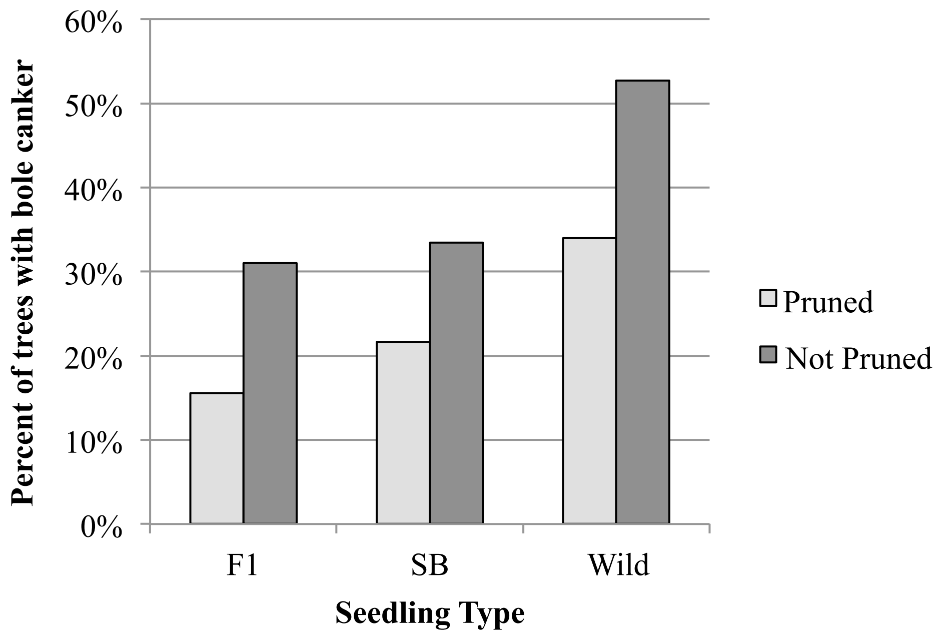

Figure 3—The percent of live trees with at least one bole canker by seedling type. F1 – F1 DGRC orchard families. SB – OP resistant families. Wild – screened susceptible families. All families are open-pollinated progeny of phenotypic selections.