Long-term Monitoring of White Pine Blister Rust Infection and Survival at 10 Sugar Pine Evaluation Sites

II. Growth and Survival of Sugar Pine through age 25 in Six Progeny Tests of Low to High Blister Rust Hazard in Southwestern Oregon

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INTRODUCTION

Large natural sugar pine near Boulder test site

Sugar pine (*Pinus lambertiana*) is an important long-lived conifer in forest ecosystems in California and Oregon. Unfortunately, it is extremely susceptible to the white pine blister rust (WPBR), caused by the non-native fungal pathogen *Cronartium ribicola*. WPBR has caused high mortality of sugar pine in many areas of Oregon, reducing its incidence in many ecosystems as well as its use in reforestation and restoration. Fortunately, there is some genetic resistance to WPBR. The USDA Forest Service (FS) and USDI Bureau of Land Management (BLM) have been working together since the mid-1960's to select candidate trees and test their progeny for resistance. The resistance screening is done at Dorena Genetic Resource Center (DGRC).

Using wind-pollinated progeny of some of the earliest selections from the Pacific Northwest Region's resistance program, BLM and FS established six field tests ('progeny' tests) in the early 1980's in southern Oregon to evaluate long-term growth, survival and field resistance to WPBR. The FS also established five provenance trials of sugar pine to examine range-wide genetic variation in this species. These trials represent 'permanent' plots with known genetic composition and planting dates. These are likely the oldest well documented multi-site test series for disease resistance in sugar pine to WPBR (and perhaps in any conifer to any non-native pathogen in western North America).

For this FHM poster, we present an overview of growth, survival, and impacts of WPBR at the six progeny test sites through age 25 (for results through age 15 see http://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb5280654.pdf). Future reports will provide additional summary of this trial series (including examination of family variation in rust resistance) and results of the provenance trials.

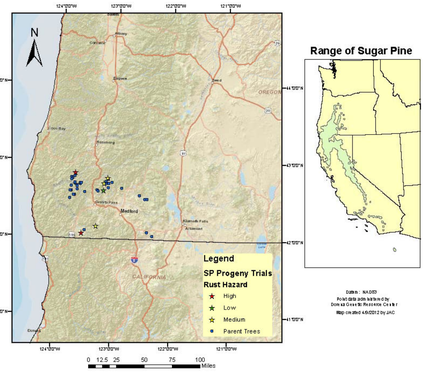

Figure 1. Location of test sites and parents represented in six progeny tests

MATERIALS AND METHODS

Sugar pine seedlings from 53 families were planted in randomized complete block designs at six sites in southwest Oregon in 1982 and 1983 (Table 1; Figure 1). The families were distributed between two Sets and the Sets planted in separate adjacent trials at each site at 2.4 x 2.4 m spacing. Up to 40 seedlings per family were planted at each site in 10 tree row plots (except at Poker where single tree non-contiguous plots were used). The parent trees for all progenies originated from southern OR (Figure 1). 31 families were common to all sites. Based on seedling screening, the families were expected to represent a range in resistance from highly susceptible to partial resistant to major gene resistance (Cr1). The sites were rated for blister rust hazard in the mid-1980's – and represented a range from low to high rust. Rust hazard was based on infection levels of 50 sampled trees from natural regeneration and the number of Ribes plants per 1/100th acre plot within the sample area. The sites were assessed for height, survival, blister rust, and other damage at approximately 5, 10, 15 and 25 years after planting. DBH was recorded at the latest assessment (2006 to 2010, depending on the site, so tree age varied from 24 to 29).

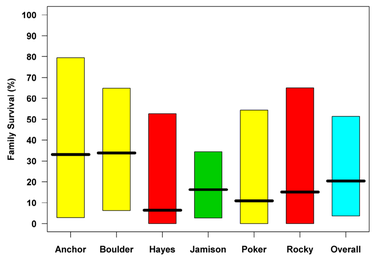

Figure 3. Mean and range of family survival at age '25' at each site and averaged over all sites.

Figure 4. Canker with little or no swelling. Aecia observed in cracks in bark.

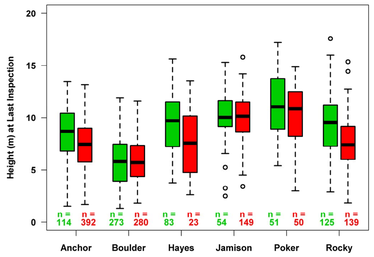

Figure5. Height (mean and range) at latest assessment (24-29 years) of surviving trees at each site. Height of cankered (red) and non-cankered (green) trees shown.

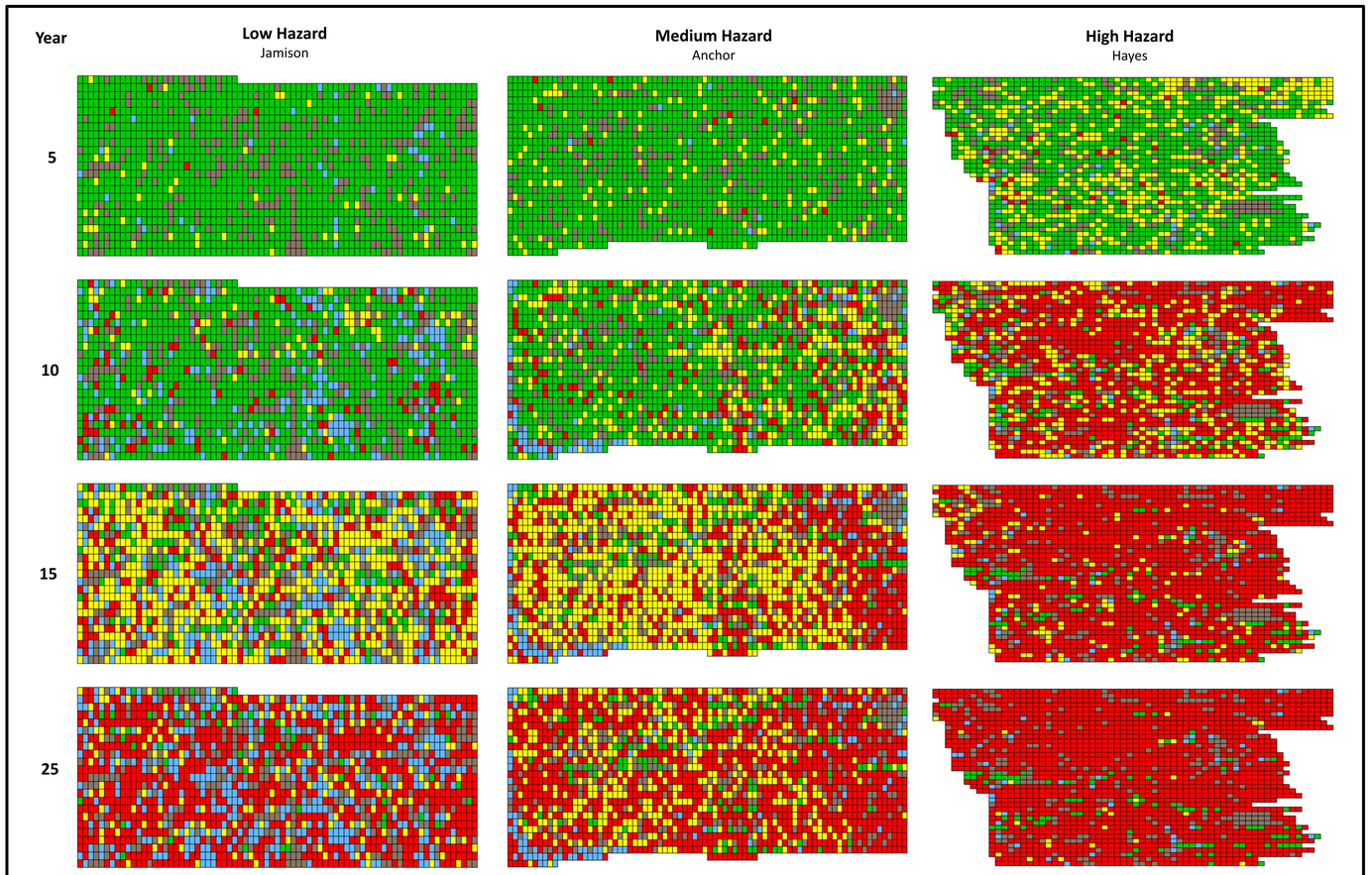

Figure 2. Temporal dynamics of blister rust infection (on individual trees) over 25 years in 3 of 6 sugar pine progeny tests.

Vertical canker, possible expression of partial resistance

Table 1. Descriptions of progeny test sites

SITE	Elevation (m)	Slope (%)	Aspect	Rust Hazard	Year Sown	Year Planted	Year of Last Inspection	# of Trees in Study[a]	# of Families Represented
Anchor	1143	10	West	Medium	1982	1983	2006	1669	49
Boulder	1097	20	East	Medium	1981	1982	2008	1750	48
Hayes	869	50	South	High	1982	1983	2010	1827	49
Jamison	853	20	South	Low	1981	1983	2010	1387	42
Poker	1280	35	West	Medium	1982	1983	2010	924	36
Rocky	975	35	North	High	1982	1983	2010	1761	49

[a]Excludes filler/replaced trees

Living and dead trees at Boulder

RESULTS

- Although the sites varied in their rust hazard (low to high), by age 25, all 6 sites had high to very high levels of blister rust infection and mortality (Fig. 2).
- Averaged over all six sites (excludes non-rust mortality):
  - 8.9% of the trees are canker-free (742/8340)
  - 13.5% are alive with cankers
  - 77.6% are dead from rust
- The sites with lower hazard ratings generally had lower levels of cankering in the early years, but the difference is much less by age 15 or 25. However, sites getting later infections (such as Boulder and Anchor) tended to have much higher survival through age 25 (Fig. 3).
- .Few new cankers were evident since the 15 year assessment.
- Some cankers produced little or no stem swelling or were only visible due to presence of aecia at the time of assessment (Fig. 4). Thus, many field assessments of blister rust may somewhat underestimate the level and impact of rust infection.
- Most cankers were low (<1.5 m) at age 15, suggesting that timely branch pruning could complement genetic resistance to increase survival.
- Mortality from other biotic and abiotic agents was low after age 5 (0.2-8.5%) except for at Jamison Gulch (23.1%).
- Averaged over the 6 sites, families varied from 40% to 96% mortality.
- Mean height of trees alive at age 25 varied from 5.9 m at Boulder to 10.7 m at Poker (Fig. 5).

SUMMARY

As anticipated, many families from these field selections are highly susceptible or have only low levels of partial resistance. Breeding in seed orchards or clones banks will be needed to increase resistance levels. The seven families with major gene (Cr1) resistance had the lowest infection and mortality levels.

Information on rust hazard can provide land managers with an additional tool for planning sugar pine reforestation or restoration efforts.

Because of the multiple sites, known genetic composition and planting dates, and assessments over ~25 years, these plantings provide the most detailed look at the impact of WPBR on sugar pine to date.

FUTURE ACTIVITIES

- Several sites have had brush removal and/or been retagged to greatly facilitate future evaluations of these trials.
- Begin breeding work with the progeny selections.
- More detailed analysis and summary including:
  - Examination of family variation in blister rust resistance, including whether there is evidence of a virulent vcr1 strain of blister rust, and whether efficacy of resistance varied by site or rust hazard.
  - Further examination of potential family variation in non-rust related mortality and possible maladaptation.
  - Comparative growth of trees with and without cankers.
- Examination and mapping of rust hazard estimates for 265 plots from the BLM's 1980s surveys.

ACKNOWLEDGMENTS

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