Status of sugar pine (*Pinus lambertiana*) at the northern edge of its range in northern Oregon

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The natural range of sugar pine.

Sugar Pine (Pinus lambertiana)

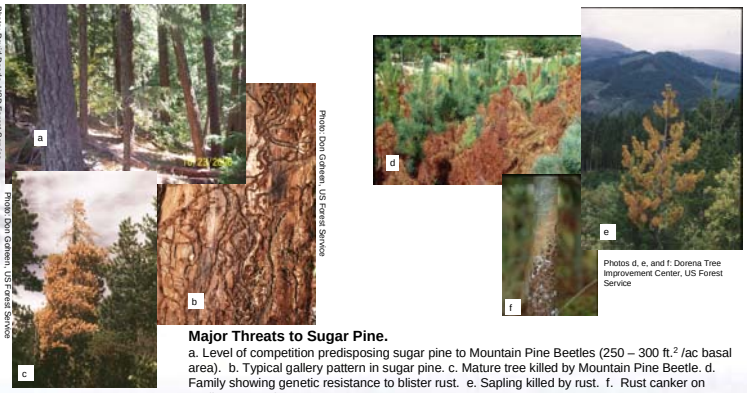
Sugar pine is the tallest and largest of all pines, frequently reaching a height of 200' and diameter of 60" at breast height. The large pendulous cones hanging from long, asymmetrical branches make it easy to identify this species from a distance.

Throughout it's natural range sugar pine populations are threatened by two particularly damaging agents: white pine blister rust (*Cronartium ribicola*) and Mountain pine beetle (*Dendroctonus ponderosae*). Blister rust, a disease introduced from Europe, can severely limit regeneration and alter natural succession. Mountain pine beetles can cause widespread mortality, often killing groups of trees. This insect is frequently attracted to trees weakened by competition stress and/or drought.

Genetically, sugar pine is one of the more variable members of the pine genus. Provenance trials have demonstrated significant, if not substantial, genetic variation associated with geographic variables, such as elevation, and major changes in climate and soils[1]. Some traits of genetic resistance to blister rust are also correlated with geographic and climatic trends. The presence of so much genetic variability associated with source location suggests that populations at or near the limits of the species range may harbor unique genetic variability, which may be important for adaptation and resistance to pests during periods of rapid climate change.

The goal of this survey is to gather sufficient information on sugar pine distribution, health, and reproduction to implement restoration projects to conserve populations and selected trees near the northern edge of the species range.

[1] Kitzmiller, Jay H. 2001. Genetic variation in Sugar Pine: results from provenance, progeny, and allozyme studies. Presentation to IUFRO Working Party 2.02.15 International conference. Breeding and Genetic Resources of Five-Needle Pines: Growth, Adaptability, and Pest Resistance. Held July 23 – 27, 2001 in Medford, Oregon USA



Major Threats to Sugar Pine.
a. Level of competition predisposing sugar pine to Mountain Pine Beetles (250 – 300 ft.^{2} /ac basal area). b. Typical gallery pattern in sugar pine. c. Mature tree killed by Mountain Pine Beetle. d. Family showing genetic resistance to blister rust. e. Sapling killed by rust. f. Rust canker on sapling sugar pine.

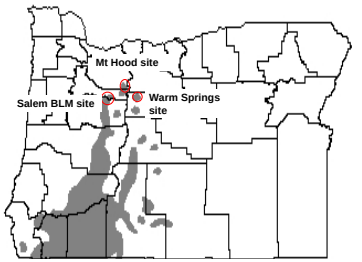
Methods

Sugar pine populations at three sites located in the northern-most part of the species range were chosen for evaluation (Confederated Tribes of Warm Springs, Mt Hood National Forest, and Bureau of Land Management Salem District). Individuals and potential stands with a sugar pine component were identified using aerial survey data, Continuous Vegetation Survey (CVS) plots, ecology plots, aerial photos, select tree locations, and local knowledge.

Field surveys used transect plots, line transects, and individual tree evaluations to obtain data on sugar pine health. Transect plots were 120' wide and consisted of sequential 200' segments (approximately 0.55 acre ir area). Basal area was estimated at the beginning of each segment. Transects were traversed until 30 live sugar pine taller than 4.5' were tallied. DBH and total height were measured and each tree evaluated for blister rust and other damaging agents.

Line transects were conducted in selected stands less than 30 years old and were traversed until 50 sugar pine, live or dead, were scored.

Individual trees previously selected for genetic resistance testing were evaluated for presence of blister rust and/or other damaging agents, crown characteristics, and competition. Crown characteristics included percent of total height with live crown or live crown ratio, and a subjective score for each 1/3 of the crown (classes were healthy, moderate, poor, and dead). Competition was inferred from basal area measurements: greater than 180 square feet of basal area indicates moderate to severe competition stress. Two 100th acre plots were also taken on opposite sides of the select tree to estimate stocking levels of trees <5" DBH.



Range of Sugar pine in Oregon State

Sugar pine populations surveyed

Results

Salem BLM: Two hundred fifteen trees were selected between 1975 and 1985 for genetic resistance testing. This survey found 69.2% (173) dead, 14% alive(35), and 16.8% (42) unknown (were not visited/not found). The live trees evaluated were generally large oldgrowth with a median dbh of 41.5" (range 18.3 – 62.8) and median height of 153.5' (55 – 232). Live trees were under moderate to severe stress from competition; median basal area was 246.6 ft.^{2} /acre (36 – 540). However, the crowns still appeared moderately healthy; median live crown ratio was 40% (20 – 80), and the frequency of a healthy crown score was 82%. The most frequently encountered damage in live trees was a dead or broken top (Fig. 1). Although difficult to identify, often blister rust is the cause of dead tops in sugar pine. Bark beetles were identified as the most common agent of death and destruction (Fig 1). Trees killed by fire were usually in, or adjacent to, burned harvest units. Most of the mortality had been dead too long to determine if blister rust was the cause of mortality. Stocking of trees<5" DBH was also high, median TPA was 775 (50 – 5350), including sugar pine in very limited amounts.

Line transects were taken in 2 plantations with sugar pine regeneration. Overall, 58.9% of the regeneration was infected with blister rust, however, there were large differences between the plantations. The first was approximately 15 years old and sugar pine mortality was only 2%, however 48% of the trees were infected with blister rust. The second plantation was a field trial to evaluate genetic resistance, and was 31 years old. Sugar pine mortality was 46% and 69% of the live trees were infected.

Mt Hood: Twenty trees were selected in 1991 for genetic resistance testing. In 2006, 21% (4) were alive and 79% (15) dead. An additional 4 trees were found that had not been selected in 1991 and these are included in this report. Live trees were generally large oldgrowth with median DBH 39.2 (range 27.8 – 49.5) and median height 115 (64 – 245). These trees were also under moderate to severe competition stress; median basal area per acre is 270 ft.^{2} /acre (35 – 360). The crowns of these trees were not in good condition; median live crown ratio was only 20% (15 – 50) and frequency of a healthy crown score was only 12.5%. Blister rust was the most frequently listed damaging agent (Fig 4). Stocking of trees<5" DBH was moderate, median TPA was 250 (100 – 1600). Only 2 sugar pine were found in the100th acre plots.

Line transects were conducted in three of five plantations planted with small amounts of sugar pine (< 100 per site) in 1994. At the first site, 93% of the sugar pine located were still alive, however 75% of these were infected with blister rust and most had basal cankers. At the second, 100% were still alive and 54% had blister rust cankers. There were no live sugar pine found at the third plantation.

Warm Springs: A previously selected group of individual trees was not available at Warm Springs, and data collection consisted of transect plots in three stands 100 years old or less and nine randomly chosen mature trees.

The mature trees were relatively large for the area, with median DBH 36.2" (range 23.1 – 45.8) and median height 96' (75 – 114). Trees were healthy and not significantly stressed; median basal area was 80 ft.^{2} /acre (27.5 – 150). Live crown ratio was 65 (50 – 85), and 89% of crown scores were moderate or healthy. The only damaging agent encountered was stem decay. Stocking of trees<5" DBH was moderately high, median TPA was 650 (50 – 2500). Naturally regenerated sugar pine was present on the 100th acre plots in limited amounts (Fig.5).

Transects were relatively similar, and results are shown in Table 1. The sugar pine in these stands were generally healthy, and not stressed. Basal areas are all less than 150 ft.^{2} /acre , and live crown ratios are all high.

Overall, populations are relatively healthy at this site. There was no evidence of blister rust found, and only minor damage from Mountain Pine beetles.

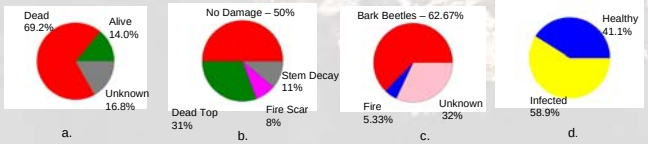


Fig.1 Mortality and damage in sugar pine at the Salem BLM site. a. Survival of mature trees. b. Causal agents of damage in live mature trees. c. Causal agents of mortality. d. Percent of regeneration infected with blister rust.

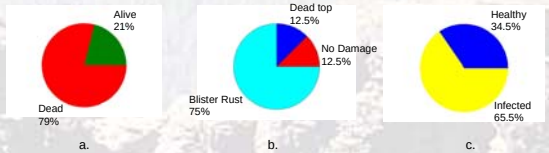


Fig.2 Mortality and damage in sugar pine at the Mt Hood site. a. Mortality in mature trees (1991 selects only). b. Causal agents of damage in live mature trees (all live trees). c. Percent of regeneration infected with blister rust.

Table 1. Median tree sizes, crown ratios (LCR), and basal area per acre for 3 transects at the Warm Springs.

Transect	%Live	DBH (in.)	Height (ft.)	LCR (%)	Basal Area	Sugar Pine <4.5'	Damaging Agents
1	78	9.3	37	75	58	8	Bark Beetles
2	94	10.2	35	80	58	2	Unknown
3	100	9.5	38	85	85	44	None

Recommendations

Salem BLM: Sugar pine populations at the Salem BLM site exhibit significant population decline. Existing live trees are stressed by competition and are threatened by mountain pine beetles, there is very little regeneration, and the surviving regeneration is infected with blister rust. An active restoration program will be needed to ensure a viable population continues at this site. Crowns of mature live trees appear to still be healthy, suggesting that thinning and reducing the basal area around the target tree would be successful. Different levels of basal area reduction around large sugar pine were evaluated in southwestern Oregon and findings indicate removing trees and shrubs just 10' out from the dripline effectively reduces sugar pine susceptibility to Mountain pine beetle[1]. Activities to restore and enhance regeneration would include pruning young trees to remove cankers and reduce entrance courts for the pathogen, and planting seedlings produced from genetically resistant seed. Any natural or artificial clearings in the forest would provide suitable habitat.

67 families from the selected parent trees were inoculated and evaluated, however early results regarding genetic resistance are inconclusive to date. Selected families are included in a seed orchard that should be producing seed soon. Given the low amounts of genetic resistance present, any seed lots used for reforestation should be comprised of a mix of seed from this seed orchard and genetically resistant sources geographically closest to the area.

[1] Goheen, Donald J. 2007. Personal communication. [2] Dorena Tree Improvement Center. 2007. Unpublished data on file.

Mt Hood: Populations at Mt Hood exhibit severe population decline. Census numbers were very low in 1991 when trees were selected, and only 4 remain alive. Existing live trees are very stressed by competition and threatened by mountain pine beetles, the live crowns are in poor health, there is very little regeneration, and the surviving regeneration is infected with blister rust. An intensive restoration program will be needed to restore this species at this site. Reducing the basal area around old mature trees has a low probability of success due to unhealthy crowns and blister rust. Pruning young trees is also likely to have little effect, as many trees are already infected with basal cankers. Most attention should be directed to re-establishing a new population using a combination of local seed from storage, seed from the BLM seed orchard, and genetically resistant sources. Of the eight families from the selected trees inoculated and evaluated for genetic resistance, none showed any evidence of resistance to the disease[2].

Warm Springs: Populations are relatively healthy at the Warm Springs site – mature trees are not overly stressed from competition and there was no evidence of any blister rust infection in any sugar pine. Local silvicultural personnel have actively pursued maintaining the presence of this species on the landscape. Stocking control is applied around mature trees, and sugar pine is included in reforestation on appropriate sites. (In 2004, 28,629 sugar pine were planted on 417 acres; over 20,000 were still surviving in 2006.) These practices should be continued. Tree selection for genetic resistance to blister rust should be pursued. Although the disease does not appear to be present at this time, any variation in genetic resistance and/or adaptive traits may be valuable to disease resistance breeding programs in a larger context.

1. Gifford Pinchot National Forest, Trout Lake, WA. 2. Westside Forest Health Protestion Service Center. Sandy, OR.