California's High-elevation White Pines: Beetle Evidence, Cone Production, and Regeneration

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Background

Concern over the health and sustainability of the high-elevation five-needled white pine populations has been increasing with greater awareness of biotic and abiotic factors that have or could have detrimental impacts on these species. The white pine blister rust pathogen (*Cronartium ribicola)*, mountain pine beetle (*Dendroctonus ponderosae;* MPB*)*, and climate change are three notable factors. From 2004 to 2006, a field survey was carried out to examine blister rust on the five high-elevation white pine species of California. In addition, the survey included data collection on beetle evidence, the presence of cones, and regeneration.

Objectives

To report on beetle evidence, cone, and regeneration data that supplemented the 2004-2006 blister rust survey on five high-elevation white pine species in California.

Data Collection and Analyses

- Number of plots: 123 across the ranges of the species. Western white pine (*Pinus monticola;* WWP*)* – 43, mainly in the Sierra Nevada; whitebark (*P. albicaulis;* WBP) – 49, mainly in the Sierra Nevada; foxtail (*P. balfouriana;* FXTL) – 12, 6 in Klamath mts., 6 in southern Sierra; limber (*P. flexilis;* LMBR) – 14 in three southern areas of the State; Great Basin bristlecone (*P. longaeva;* BCP) – 5 in south-eastern California.
- Plot size - 30 m by 50 m, or longer; at least 30 live trees.
- Tree data: species, live status, presence/absence of mountain pine beetle and cones.
- Plot data: slope, aspect, elevation, seedling/sapling density (<1.37 m tall), and 30-year climate data.

Data analyzed - percentage of trees with MPB evidence or cones, and seedling/sapling densities (# per hectare).
Comparisons of ranked data – Between plots of 1) western white and whitebark pine, and 2) for those 2 species, between northern and southern Sierra plots, and then western and eastern Sierra plots. Wilcoxon rank-sum tests.
Regressions - Evaluate how well data are correlated to slope, aspect, elevation, and annual minimum & maximum temperatures, relative humidity, precipitation, number of wet days, growing degree days. Plots with non-zero values used in analyses. Data transformations made on beetle and seedling data. Stepwise regressions done. Factor enters or stays in model if $p \leq 0.15$. Overall model considered significant if $p \leq 0.10$.

Summary of Results[1]

Beetle Evidence

- Percentage of plots with beetle evidence - 43%.
- Beetle-attacked trees – Plot mean, 5%; plot range, 0 to 32%.
- WBP and WWP – **(a)** Percentage of plots with MPB evidence, 63 and 53% each; mean percentage of beetle-attacked trees, 7 and 5% each. **(b)** Percentage of plots with MPB evidence higher in the north-central Sierra than in the southern Sierra (North: WBP, 78%; WWP, 70%. South: WBP, 35%; WWP, 40%). **(c)** Significantly higher percentage of trees with MPB evidence in the north-central Sierra plots than in the southern Sierra plots (Means: 9% vs. 4%). Also, eastern Sierra plots were significantly higher than western ones (Means: 11% vs. 4%).
- FXTL, LMBR - 2 plots each with MPB evidence.
- BCP - No MPB evidence in plots.

Cone Production

- 122 of the 123 plots had trees with cones on them.
- WBP and WWP - **(a)** Over half of the plots had more than 30% of the trees with cones. **(b)** Mean percentage of trees with cones was 34% . **(c)** No significant differences found between plots of the two species, or the latitudinal (N vs. S) and longitudinal (W vs. E) comparisons.
- FXTL, LMBR, BCP – More than 30% of the trees had cones in all but three plots.
- FXTL - Southern Sierra plots had significantly higher % of trees with cones than Klamath plots (Means: 72% vs. 39%).
- LMBR - Percentage of trees with cones averaged 38 to 54% across plots in the three limber regions.
- BCP - Trees with cones averaged 77% across plots.

Seedling/sapling Densities

- Percentage of plots with seedlings/saplings - 87%.
- Densities – Mean, 25 to 148 per ha; range, 0 to an estimated 1,333 per ha (3 WWP plots had the highest number)
- WBP and WWP – No significant differences found between plots of the two species, or the latitudinal (N vs. S) and longitudinal (W vs. E) comparisons.
- FXTL - Klamath plots ranked significantly higher in density than southern Sierra plots (Means: North, 120; south, 28).
- LMBR and BCP - Densities averaged 54and 25 per ha each.

Site/Climate Regressions with Beetle Evidence

- WBP – Relative humidity, minimum temperature (min. temp.), and aspect were the strongest contributors (r^2: 0.26 - 0.30) in simple regressions (SREG); in a multiple regression (MREG), those factors resulted in an r^2 of 0.49.
- WWP – Slope, the only significant factor in a SREG ($r^2 = 0.15$). In a MREG, slope, relative humidity, and elevation had an $r^2 = 0.45$; add number of wet days, $r^2 = 0.51$, but last two factors moderately correlated ($r = -0.59$).

Site/Climate Regressions with Cone Data

- WBP - The few significant SREGs and MREG were weak.
- WWP - A few SREGs weak. MREG of slope, min. temp, relative humidity, min. temp. squared, and aspect had an $r^2 = 0.52$.
- FXTL - Highest $r^2 = 0.60$ of the SREGs. A MREG of min. temp. squared, slope, and min. temp. had an $r^2 = 0.86$.
- LMBR - Quadratic model with slope, $r^2 = 0.33$ ($p \leq .11$).
- BCP - One significant SREG, $r^2 = 0.87$. A MREG with elevation and min. temp. had an $r^2 = 0.997$.

Site/Climate Regressions with Seedling/Sapling Densities

- WBP – Highest $r^2 = 0.20$ of the SREGs. A MREG of elevation, and slope had an $r^2 = 0.26$; add min. temp, $r^2 = 0.31$. Elevation and min. temp. correlated ($r = -0.57$).
- WWP – Highest $r^2 = 0.47$ of the SREGs. A MREG with number of wet days had an $r^2 = 0.47$; add slope, $r^2 = 0.55$. The two factors are correlated ($r = -0.53$).
- FXTL - Highest $r^2 = 0.39$ of the SREG and MREG models with maximum temperature.
- LMBR – No significant SREG or MREG.
- BCP – One significant SREG, $r^2 = 0.83$. A MREG with precipitation and slope had an $r^2 = 0.96$. Add min. temp., $r^2 = 1.00$; possible correlation with precipitation ($r = 0.78$, $p \leq 0.12$).

Summary of Regression Analyses

Regression models of site and climate factors with beetle evidence, cones, and seedling/sapling density differed by species and in their strength and the number of significant factors. Data is based on one visit to each plot, so more data would be needed to make inferences for multiple years.

[1]*Results presented as initial evaluations.*

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