Natural and anthropogenic threats to California's endemic foxtail pine (*Pinus balfouriana)*

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Background

California is unique in its white pine diversity, having six of the nine species found in the United States. These are distributed across a range of montane ecosystems within the State. White pine blister rust (WPBR), caused by the exotic pathogen *Cronartium ribicola*, severely threatens white pine sustainability in parts of the western US. When coupled with climatic warming (e.g., protracted drought periods) and climate-driven outbreaks of native insects, such as mountain pine beetle (*Dendroctonus ponderosae*; MPB), these stressors pose significant challenges to high-elevation forests. In California, WPBR has been found in four of the six white pine species, including California's endemic foxtail pine (*Pinus balfouriana)*. Noteworthy of foxtail pine is its limited, disjunct distribution at high elevations in the northern coast-interior and southern Sierra Nevada mountains . This geographic separation also corresponds to genetic differences with the recognition of a northern and southern ecotype.

Data from a recent California high-elevation white pine survey documented rust infection on foxtail pine in plots of the northern stands, but not in the southern ones. The average infection in the north was 12% (range: 0-32%). Current information on the status of foxtail pine relies on anecdotal observations and relatively few plots. Supplementing with additional plots would provide more information on WPBR, beetle activity, and population dynamics of this endemic species. Such information is basic to developing conservation and management strategies, as this species is part of the larger concern about the health of all high-elevation white pine species.

Project Objectives

- **Increase the number of long-term monitoring plots in foxtail pine stands.**
- **Develop demographic models for foxtail pine to evaluate population dynamics**
- **Supplement current information on white pine blister rust in foxtail pine with other stressors such as mountain pine beetle.**

Methods

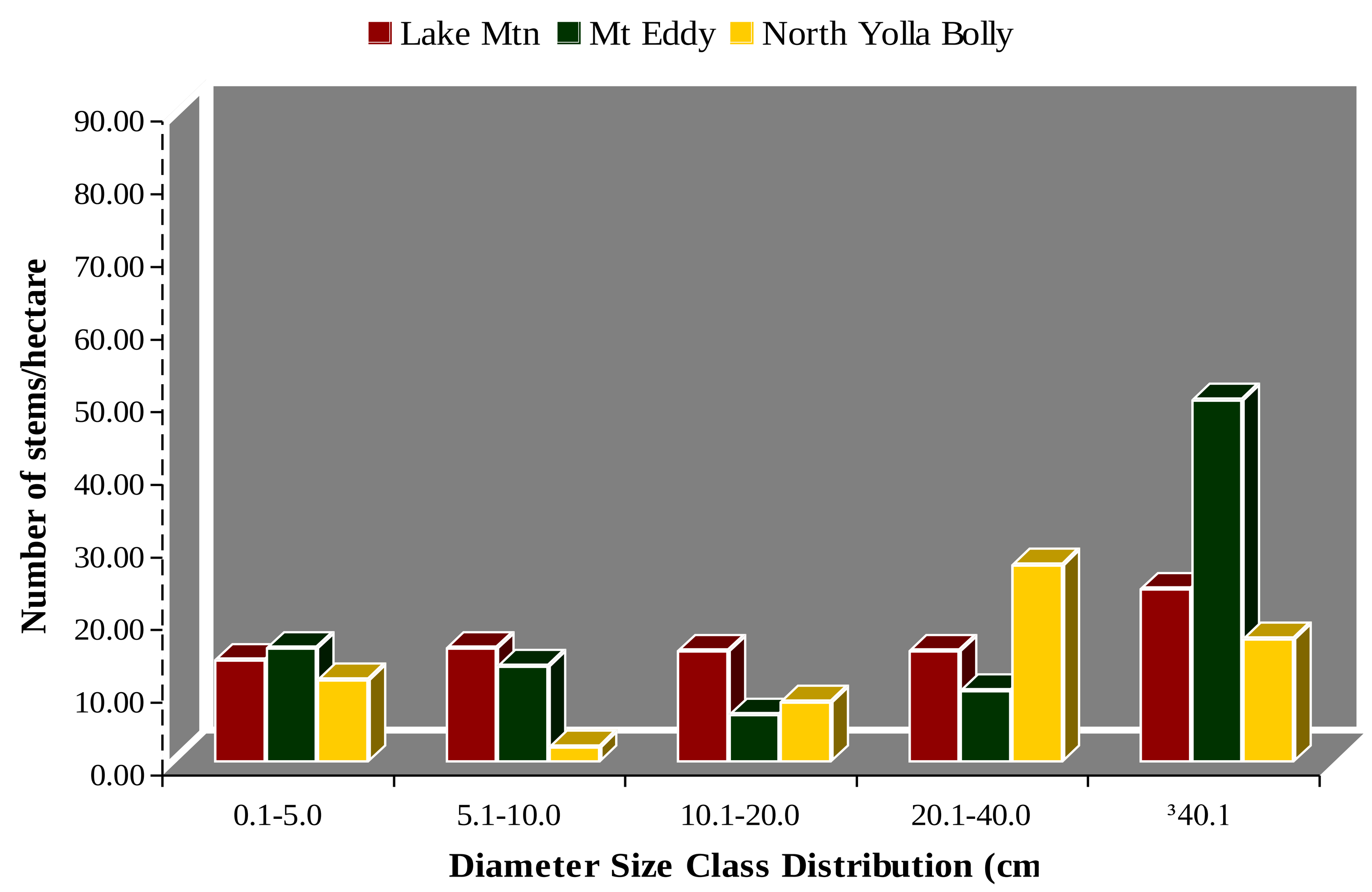
- **Survey plots:** **30 by 50 m transect plots, with size adjustments as needed, and each plot containing at least 30 live foxtail out of 50 trees total.**

  ***Tree data*: Diameter, tree status (live, dead), crown condition (% of crown dead, dying, damaged, infected), WPBR (yes/no), canker location, number, and status (active or not), other rust symptoms, unknown branch flagging, other pathogens and insects (e.g., MPB), and cones (yes/no). *Plot data:* Number of seedlings/saplings and their status (live/dead; rust/no rust), *Ribes* species (%cover, rust/no rust), plot location, slope and aspect, other tree species, aecia phenology, and presence/absence of *Castilleja*, *Pedicularis*, and Clark's nutcrackers.**
- **Demographic plots:** **Within a stand, 3 plots from 0.5 to 1.0 hectares were established in which tree and environmental data were collected and trees mapped. Recruitment was evaluated in each plot with 3 nested regeneration plots (15 x 15 m). *Demographic data*: Tree and plot data similar to survey plots. Additional data on regeneration: live/dead, cause of mortality, height, diameter, whorl count, crown condition, insect and/or non-rust disease, microsite habitat, litter depth, geology.**

Results

Demographic data from 6 sites show that size class distribution and density differ between the two ecotypes and the three southern plots are also more variable (Figure 1). Noteworthy is the population structure at Siretta Peak where stem density was low across all diameter classes and seedling recruitment was nearly non existent (Figs. 1 & 2). This pattern may be indicative of a declining population. Seedling recruitment was low and infrequent in the northern Yolla Bolly plot, but it was relatively high in 7 years since 1999 on Mt. Eddy (Fig. 2). Recruitment appears to be episodic and low in the remaining plots. Demographic models will be used to assess population dynamics (e.g., declining, growing, or stable).

FIGURE 1. Foxtail pine size structure from northern (Lake Mtn, Mt Eddy and North Yolla Bolly) and southern (Onion Valley, Cottonwood Pass and Siretta Peak) populations.



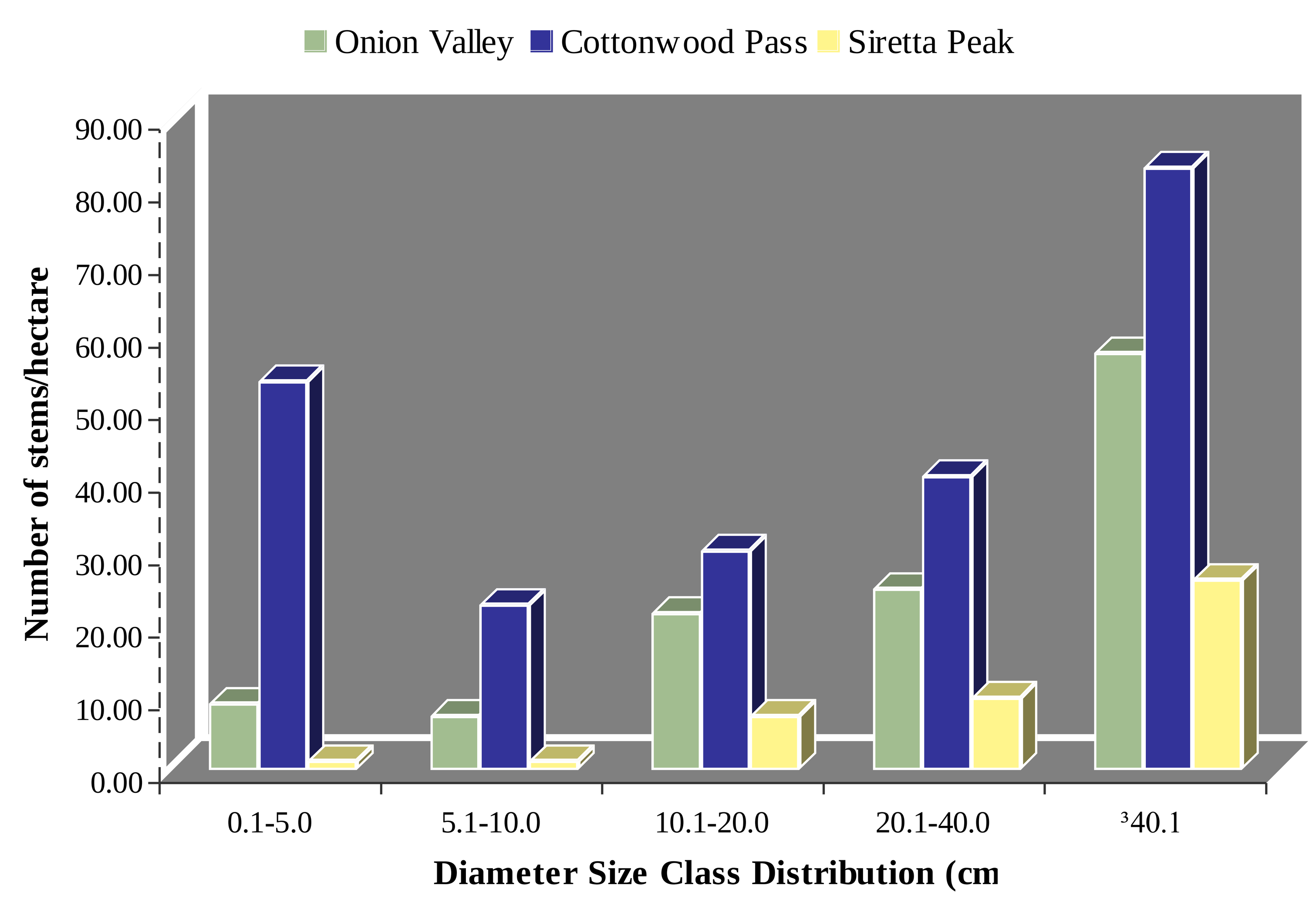
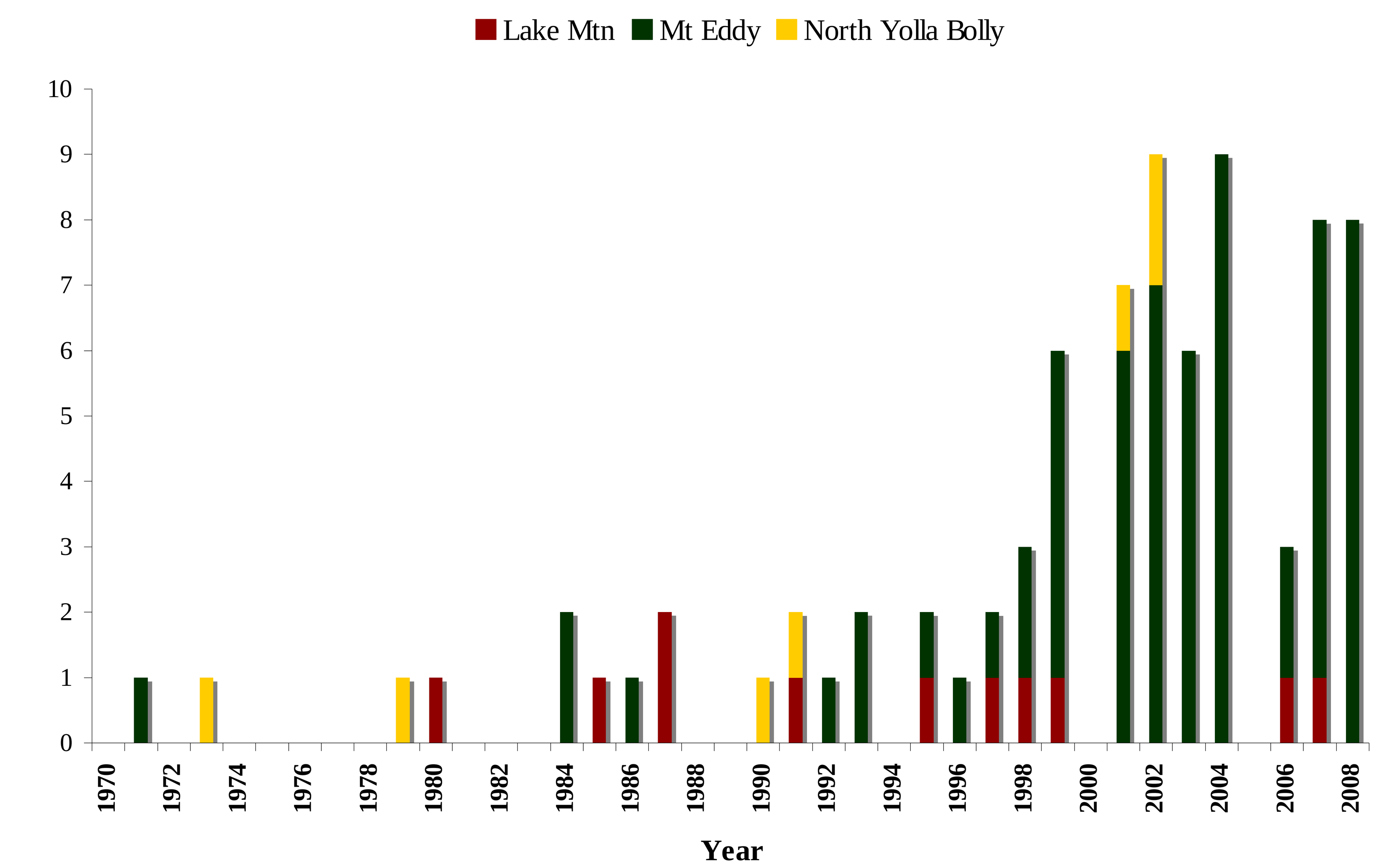
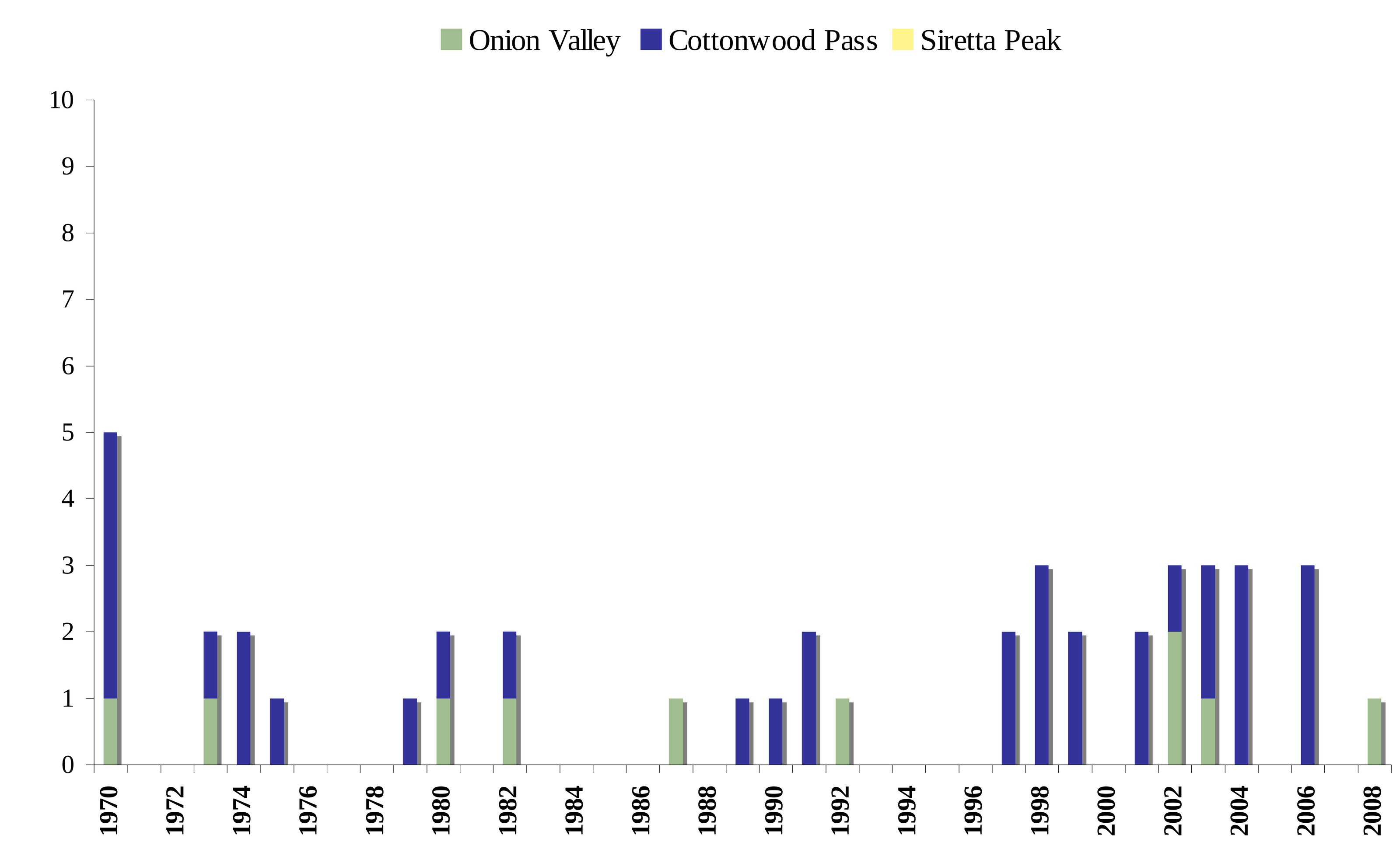


FIGURE 2. Foxtail regeneration and establishment patterns; total number of recruits (0.20 ha/population) per year for each population.





Rust was present in 5 of the 21 survey plots and only in plots of the northern foxtail pine. It was found in 2 additional stands where demographic plots were established—again, in northern populations. The northern plots also had higher seedling densities (Tables 1 & 2). However, the southern plots had higher levels of MPB and mortality, although these were below 9% (Tables 1 &2).

TABLE 1. Survey plot summary (n=21).

Ecotype	% WPBR	% MPB	% Mortality	Seedlings/ha
Northern	1.9	1.4	5.8	166.0
Southern	0.0	5.6	8.7	91.0

TABLE 2. Demographic plot summary (n=6).

Ecotype	% WPBR	% MPB	% Mortality	Seedlings/ha
Northern	7.3	1.1	1.3	79.0
Southern	0.0	3.6	3.8	35.0

Cone Collections & Gene Conservation

In Fall 2009, cone collections were made from two locations not previously collected from by the USDA-FS Region 5 Genetics group:

- **Mt Eddy (northern ecotype) - 25 families**
- **Cottonwood Pass (southern ecotype) - 23 families**

Acknowledgments: Funding provided by USDA Forest Service, Forest Health Monitoring and Protection Programs. C. Jensen, S. Lynch, A. Wickland, T. Burt, and H. Denno for field assistance. USDA-FS R5 ecologists, biologists, natural resource staff, and wilderness rangers for consultations. D. Davis and T. Burt for foxtail cone collections and D. Welty for cone processing. A. Eckert for foxtail distribution, ecology and location information.