

9. THREATS, STATUS & MANAGEMENT OPTIONS FOR BRISTLECONE PINES AND LIMBER PINES IN SOUTHERN ROCKIES

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High-elevation white pines define the most remote alpine-forest ecotones in western North America yet they are not beyond the reach of a lethal non-native pathogen. The pathogen (*Cronartium ribicola*), a native to Asia, causes the disease white pine blister rust (WPBR) and was introduced into western Canada in 1910. Whitebark (*Pinus albicaulis*) and limber (*P. flexilis*) pines have been infected for over 50 years in the northern Rockies and are currently experiencing top-kill and mortality as a result of the disease (see Tomback et al. 2001). The disease was found in southern Wyoming over 30 years ago and in northern Colorado in 1998 on limber pine (Johnson and Jacobi 2000). Rocky Mountain bristlecone pine (*P. aristata*) was first found infected in south-central Colorado in 2003 (Blodgett and Sullivan 2004). The pathogen continues to spread and threaten the extensive high elevation pine forests of the southern Rockies (Burns 2006). Approximately half of the distribution of bristlecone, limber and southwestern white pine in Colorado have environmental conditions conducive to the invasion of WPBR (Kearns 2005; Howell, Burns and Kearns 2006). Given the unique ecological roles played by these species, tree mortality and reduced regeneration success caused by blister rust will affect biodiversity, watershed stability, forest recovery after fire, wildlife and recreation (Schoettle 2004a).

The program:

The goal of our program is to develop tools, frameworks and guidelines from research on the ecology, physiology, pathology and genetics of high elevation five-needle pines to facilitate prioritization and implementation of proactive management to mitigate impacts of WPBR. Learning from the experience in the Northern Rockies, we have developed an integrated interdisciplinary program to develop science-based management options to proactively prepare the landscape for invasion to alter the outcome of the invasion on ecosystem services (Schoettle, 2004b; Schoettle and Snieszko, *in press*). The management strategy focuses on early intervention to accelerate the establishment of rust resistant individuals by providing trees at a high susceptible life stage (young) to promote and accelerate rust-resistance selection while retaining older trees to hold site occupancy and provide ecosystem services during pathogen invasion (Schoettle, 2004b; Schoettle and Snieszko, *in press*).

Research support:

Generation of a mosaic of diverse age classes on the landscape to accelerate rust-resistance selection while sustaining ecosystem function requires appropriate silviculture techniques. To aid in the development and testing of silviculture prescriptions for this objective, spatial and temporal dynamics of regeneration of limber and bristlecone pine are being defined. Experimental field and greenhouse studies are underway to define specific factors that influence successful pine germination and establishment. To improve decision making ability and prioritization of intervention, the frequency of rust resistance is being estimated for bristlecone and limber pine populations of the Southern Rockies. Adaptive traits among sites and families are also being studied. The physiological cost of resistance is being studied to determine if the fundamental niche of the species will change in the presence of the rust. This information can be combined with climate change estimates to improve seed transfer and outplanting procedures. Guidelines for selecting putatively resistant seed trees are being developed for low rust incidence areas.

Increasing awareness and integration:

Involvement and acceptance by diversity constituents is essential if these threatened ecosystems are to be sustained into the future. The Annual Central Rockies White Pine Health Meeting was established in 2000 to facilitate the interaction of researcher, managers and forest health professionals. Meetings are held at Colorado State University each winter. Partnering with local chapters of national and state groups and organizations and local interested parties has facilitated the transfer of new research findings and

management options to land managers and the public through field tours and site visits. We have also developed an educational website to increase the awareness of the high elevation white pine species, their ecosystems and the threats that face them (Schoettle et al. 2006).

Management outcomes:

Prescriptions are being implemented to stimulate regeneration of limber and bristlecone pine in Colorado. Pruning projects are underway to help slow the progression of the disease in areas with high values trees such as campgrounds and archeological sites. Seed collections have begun to archive genetic diversity and prepare for artificial regeneration projects to restore impacted areas.

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