

Limber Pine Forests on the Leading Edge of White Pine Blister Rust Distribution in Northern Colorado

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Introduction

The combined threats of the current mountain pine beetle (*Dendroctonus ponderosae*, MPB) epidemic with the imminent invasion of white pine blister rust (caused by the non-native fungus *Cronartium ribicola*, WPBR) in limber pine (*Pinus flexilis*) forests in northern Colorado threatens the limber pine's regeneration cycle and ecosystem function. Over one million hectares of Colorado forests have been infested by MPB between 1996 and 2008 (U.S. Department of Agriculture 2010). Limber pine makes up only approximately 3 percent of this infested area (U.S. Department of Agriculture, unpublished data), but is a disproportionately important component of forested ecosystems for recreation, biodiversity, and watershed protection (Schoettle 2004). White pine blister rust was first detected in northern Colorado in 1998 on limber pine and continues to spread (Johnson and Jacobi 2000; Blodgett and Sullivan 2004; Kearns and Jacobi 2007).

Proactive strategies to sustain limber pine in the southern Rocky Mountains are focused at the forefront of WPBR invasion in Colorado and include disease monitoring plots, tree seed collections, protection of seedtrees from MPB, and WPBR resistance screening trials (Schoettle and Sniezko 2007; Burns and others, submitted; Schoettle and others, The Proactive Strategy for Sustaining Five-Needle Pine Populations, this proceedings). This study is adding information on disturbance and stand characteristics to compliment these ongoing efforts and improve land manager's abilities to assess the risks and better evaluate proactive management options to sustain limber pine in northern Colorado. Objectives of this survey in limber pine seed collection sites throughout northern Colorado are to: 1) quantify the amount of understory (height < 137 cm), intermediate (diameter at breast height [dbh] > 0 and < 10 cm), and overstory (dbh ≥ 10 cm) limber pine and other tree species, 2) identify site, stand, and climate characteristics related to limber pine advanced regeneration densities, 3) determine stand resilience to MPB and predict potential post-MPB stand structure and species composition, and 4) examine age, height, growth, microsite, and stand relationships of understory trees to evaluate whether limber pine advanced regeneration will release with overstory tree removal due to MPB-caused mortality. In this paper, we will report some preliminary findings for objective one and discuss the implications of the other objectives.

Methods

In 2009, a network of 29 sites in limber pine forest (2450–3420 m in elevation, 9–12 hectares per site) was surveyed for site and stand characteristics and disturbances (Fig. 1). Seventeen of the sites were in Rocky Mountain National Park and 12 were in the Roosevelt and Pike National Forests. These locations are also limber pine seed collection sites from which seeds are being tested for resistance to WPBR (Schoettle and others 2009; Schoettle and others, Preliminary Overview of the First Extensive Rust Resistance Screening Tests of *Pinus flexilis* and *Pinus aristata*, this proceedings). At each site, 10 plots (0.02 ha each) spaced 50 m apart over two transects were assessed. Overstory, intermediate, and understory tree density, tree health, crown class, and biotic damage were recorded. Information recorded specifically on limber pine included: microsite, tree age estimate, vigor assessments for understory trees, and reproductive effort for all tree sizes. Percent ground cover and canopy cover were also estimated.

Results and Discussion

Applying the major habitat types defined by Peet (1981), the habitat types of our 29 sites were montane limber pine forests (12 sites), limber pine forest type with Engelmann spruce (*Picea engelmannii*) and subalpine fir (*Abies lasiocarpa*) (limber pine forest type) (9 sites), and subalpine limber pine forests (8 sites). Sites in the montane limber pine forest type were less than 3100 m in elevation and had highly variable limber pine understory density with an average of 347.7/ha (standard error [SE]=134.2) (Table 1). Ponderosa pine (*Pinus ponderosa*) and Douglas-fir (*Pseudotsuga menziesii*) were significant portions of the understory, intermediate, and overstory trees in montane limber pine forest types. The density of understory limber pine in the limber pine forest type was also variable and averaged 491.8/ha (SE=201.0) (Table 1). Engelmann spruce and subalpine fir were large components of the understory, intermediate, and overstory trees in both the limber pine forest type and subalpine limber pine forest type. Lodgepole pine (*Pinus contorta*) occurred throughout the elevational range of the sites except at two treeline krummholz sites and the lowest elevation site.

The relationship between limber pine intermediate and understory density with the density of overstory limber pine

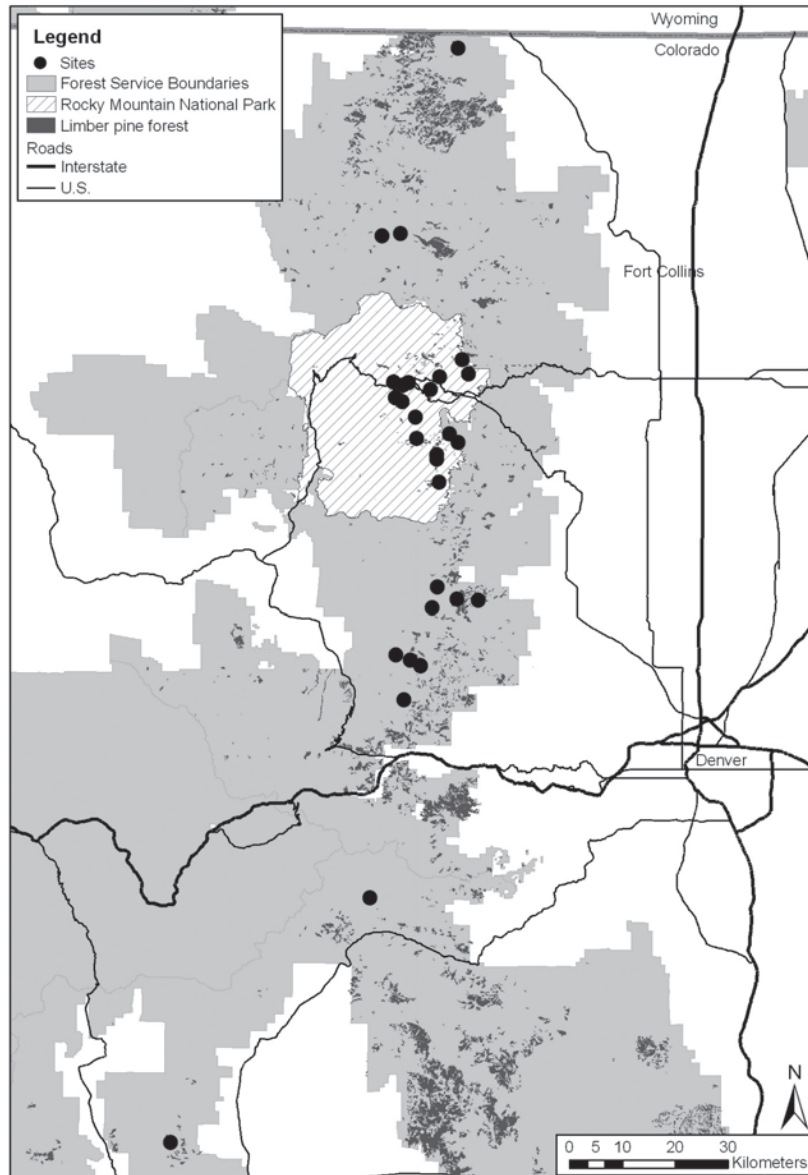


Figure 1. Map of study area with limber pine sample sites in the Arapaho-Roosevelt and Pike-San Isabel National Forests and Rocky Mountain National Park, Colorado.

Table 1. Mean (standard error) density of elevation, live limber pine, and percent of limber pine killed by mountain pine beetle from 2005 to 2009 by habitat type as defined by Peet (1981)^a in the Roosevelt and Pike National Forests and Rocky Mountain National Park, Colorado.

	Habitat type ^a		
	Montane limber pine (n=12)	Limber pine with spruce and fir (n=9)	Subalpine limber pine (n=8)
Elevation (m)	2803 (56)	3098 (52)	3286 (36)
Overstory limber pine/ha	186.1 (52.6)	354.2 (57.2)	286.0 (60.9)
Intermediate limber pine/ha	179.9 (40.7)	262.5 (117.3)	238.7 (71.8)
Understory limber pine/ha	347.7 (134.2)	491.8 (201.0)	399.1 (61.4)
Percent overstory limber pine killed by MPB	2% (1)	6% (2)	7% (3)

^a Overstory, intermediate, and understory trees are defined as: dbh $\geq$ 10 cm, dbh between 0 and 10 cm, and height $<$ 137 cm, respectively

will be important in understanding the regeneration dynamics of our study area. Analyses to define significant site and stand characteristics associated with greater understory limber pine densities are ongoing.

Mountain pine beetle-caused mortality has the potential to significantly alter the species composition and stand characteristics of northern Colorado limber pine forests. Limber pine and other MPB-host trees (ponderosa, lodgepole, and Rocky Mountain bristlecone (*Pinus aristata*) pine) comprised over 50 percent of overstory trees at all sites and all host species were being infested by mountain pine beetle. As of 2009, limber pine mortality caused by MPB was present at 15 of the 29 sites in all forest types except at treeline krummholz. The average percent of overstory limber pine killed by MPB were 2 percent, 6 percent, and 7 percent in the montane, limber pine, and subalpine forest types, respectively (Table 1). The proportion of limber pine being infested by MPB on these sites is similar to the proportion of other MPB-host trees being infested. The MPB epidemic is continuing to build in this region as indicated in Aerial Survey data from 2009 and 2010 (U.S. Department of Agriculture 2010). The MPB-caused mortality of limber pine seedtrees necessitates the urgency for genetic conservation of limber pine to provide material for assessing the frequency of resistance to WPBR in these populations (Schoettle and others 2009; Schoettle and others, The Proactive Strategy for Sustaining Five-Needle Pine Populations, this proceedings).

Following the current MPB outbreak, both competition from other tree species and the likelihood of the remaining live limber pine component to release will determine whether sites will continue to sustain limber pine. The MPB outbreak may result in an acceleration of succession from MPB-host trees to more shade tolerant non-MPB-host tree species in some forest types (Hawkes and others 2003; Sibold and others 2007). However, the MPB outbreak may also act as a thinning event that could promote resilience and short-term health of the remaining live limber pine (Millar and others 2007). Due to the long maturation time for limber pine to be reproductive, it could take up to 50 years for young limber pine to produce seed cones (McCaughey and Schmidt 1990). The reduction of overstory limber pine density across the landscape and its delayed maturation may leave limber pine in northern Colorado susceptible to stresses, such as WPBR, competition, and climate change (Millar and others 2007). A proactive strategy to sustain limber pine in Colorado provides integrating information on the frequency of genetic resistance to WPBR, the potential density of live limber pine component after the MPB outbreak, reproductive potential of seedtrees that escape MPB infestation, and the site characteristics associated with limber pine advanced regeneration density (Schoettle and Sniezko 2007; Schoettle and others, The Proactive Strategy for Sustaining Five-Needle Pine Populations, this proceedings). When complete, this study will contribute key information to assist managers in developing and prioritizing management options for limber pine in the southern Rocky Mountains.

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