

INTRODUCTION

As forest communities continue to experience interactions between climate change and shifting disturbance regimes, there is an increased need to link ecological understanding to applied management. Whitebark pine (*Pinus albicaulis*) and limber pine (*P. flexilis*) are important high-elevation five-needle pines in the central and northern Rocky Mountains. Populations of both species face considerable challenges from mountain pine beetle (*Dendroctonus ponderosae*), white pine blister rust (*Cronartium ribicola*), and successional displacement resulting from altered natural disturbance regimes.

Many studies of these pines have focused on relatively narrow portions of what are, in fact, considerable ranges in stand structure and species composition. Both of these species occupy sites in addition to the “high and dry” habitats with which they are typically associated. In addition, both species are represented in stands ranging from pure to mixed-species and from single- to multi-cohort.

This project has contributed to our understanding of the complexity of whitebark and limber pine stand dynamics, including successional trajectories and age-class distributions. This insight is key to the development of effective management strategies and silvicultural prescriptions. The objectives of the study were (1) to characterize stand structure, species composition, and the influence

of important environmental factors (e.g., elevation, aspect, temperature, and precipitation) for whitebark and limber pine across the Interior West, including important variations in stand dynamics for the two species; and (2) to develop silvicultural recommendations addressing the challenges to effective management of whitebark pine and limber pine.

METHODS

The data used in our analysis of whitebark pine were drawn from a database of U.S. Department of Agriculture, Forest Service, Forest Inventory and Analysis (FIA) surveys (Woudenberg and others 2010) conducted across the range of whitebark pine in the Western United States (California, Nevada, Oregon, Washington, Idaho, Montana, and Wyoming). For our analysis of limber pine, a query of the FIA Database located all FIA plots containing limber pine in the overstory and regeneration layer within the Intermountain West.

The current FIA sampling design is approximately 0.067 ha and includes four 7.32-m radius subplots. On each subplot, overstory trees > 12.7 cm d.b.h. (diameter at breast height) were measured. Each subplot contains a 2.073-m radius circular microplot where saplings (trees between 2.4 cm and 12.7 cm d.b.h.) and seedlings (trees < 2.4 cm d.b.h.) were measured. Only Phase 2 (annual inventory) data were used in our analyses. Some States were in the process of beginning their second round of annual inventories resulting

CHAPTER 15.

Composition and Structure of Whitebark and Limber Pine Stands in the Interior West and the Silvicultural Implications (Project INT-EM-B-14-01)

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in 2 years of data. The most recent sampling year was used so there were no repeated measurements within the dataset.

FIA plots measured since 2000 follow a mapped-plot design, meaning that a plot footprint can sample forest and nonforest, or stands of differing composition. The contrasting units are referred to as “conditions,” and they are uniquely identified within a plot in the FIA database. Characteristics normally attributed to stands in other inventories, such as forest type or site index, are assigned to FIA conditions. Among condition-level variables is the proportion of the plot footprint that the condition occupies, and the sum of all condition proportions on a plot equals 1.0.

For all conditions with a whitebark or limber pine component, we obtained the following variables for trees > 1.0 inch (2.54 cm) d.b.h.: species, diameter, height, and individual tree cubic-foot volume. FIA data include volume on a per-tree basis that is calculated using local volume equations (Woudenberg and others 2010). We calculated basal area on a per-acre (0.4047 ha) basis separately for the two target species and all species combined and computed the target species composition on a basal area basis.

RESULTS AND DISCUSSION

Whitebark Pine

Whitebark pine is both a keystone and a foundational species that is a candidate for protection under the Endangered Species Act. Threats to whitebark pine include mountain pine beetle and white pine blister rust. A density management diagram was constructed for whitebark pine and used to assess density-related aspects of this complex system. There are tradeoffs in managing stand relative density with the objectives of maintaining resistance to attack by the mountain pine beetle, maintaining resilience with respect to the potential for Clark’s nutcracker-mediated (*Nucifraga columbiana*) natural regeneration, and maintaining genetic resistance to white pine blister rust.

The density management diagram allows the graphical display of stand relative densities thought to be critical for maintaining resistance and resilience of whitebark pine stands (fig. 15.1). While the relative density thresholds are based on only two studies, they are conservative and appear reasonable. Relative density needs to be low enough to maintain resistance to attack by the mountain pine beetle (Perkins and Roberts 2003), yet high enough to maintain resilience with respect to

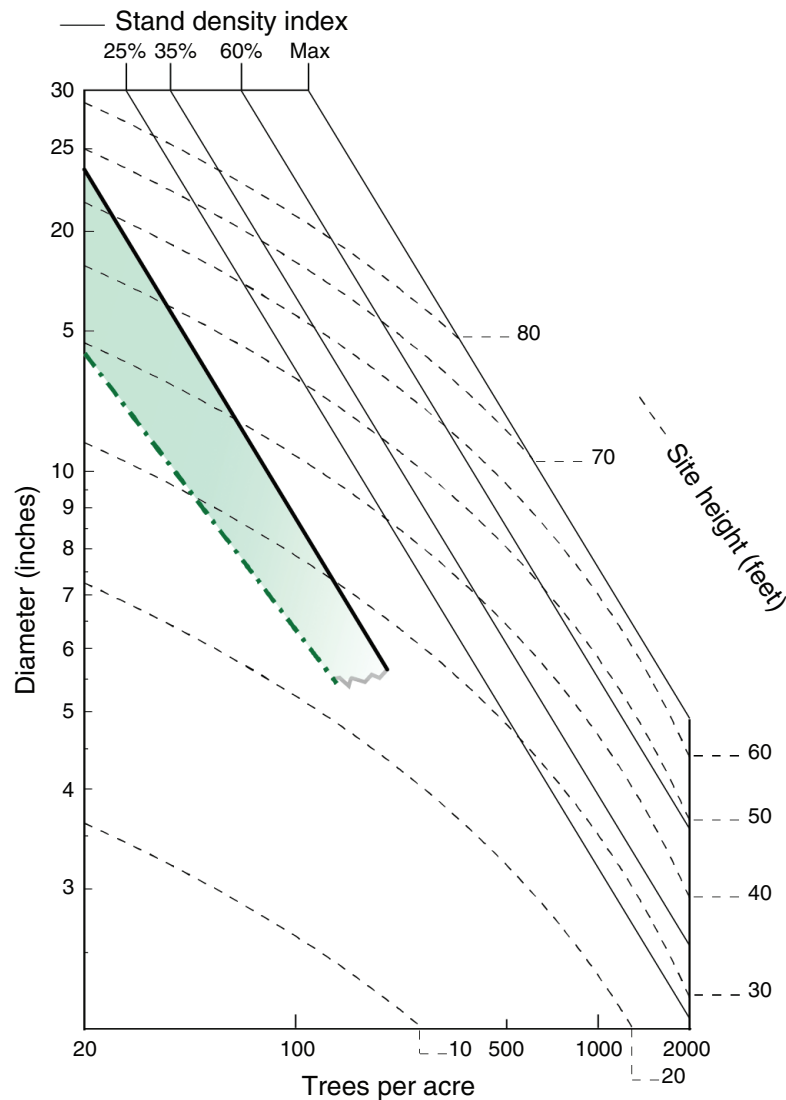


Figure 15.1—Whitebark pine density management diagram with superimposed relative density lines corresponding to mountain pine beetle (MPB) susceptibility (solid black line, after Perkins and Roberts 2003) and stocking necessary for maintenance of Clark's nutcrackers (dashed green line, after McKinney and others 2009).

the potential for Clark's nutcracker-mediated natural regeneration (McKinney and others 2009). Density management plans also need to be developed in the context of white pine blister rust. Thinning to increase resistance to mountain pine beetle attack will ideally be done so that whatever genetic resistance to white pine blister rust exists in the population will not be negatively affected (Keane and others 2012: 80).

Limber Pine

Limber pine has been described as a harsh environment specialist, competitively excluded from mesic environments. We used the FIA database to test the competitive exclusion hypothesis across a broad elevational and geographic area within the Intermountain West. We anticipated that competitive exclusion would result in limber pine's absence from mid-elevation forest communities, creating a bimodal distribution, i.e., high and low elevations. Using the FIA database, limber pine was observed to occur with 22 different overstory species, which represents a surprising number of the woody, overstory species commonly observed in the Intermountain West. There were no biologically significant relationships between measures of annual precipitation, annual temperature, or climatic indices (i.e., Ombrothermic Index) and limber pine dominance. Limber pine was observed to be a consistent component of forest communities across elevation classes. Of the plots that contained limber pine regeneration, nearly half did not have a live or dead limber pine in the overstory. However, limber pine regeneration was greater in plots with higher

live limber pine basal area and higher average annual precipitation. Our results suggest limber pine may be better described as a habitat generalist instead of a specialist (Windmuller-Campione and Long 2016).

CONCLUSIONS

Goals for the management of whitebark pine include maintaining resistance to attack by the mountain pine beetle, maintaining resilience with respect to Clark's nutcracker-mediated natural regeneration, and maintaining genetic resistance to white pine blister rust. Achieving these goals will require careful attention to critical tradeoffs in stand relative density. If relative density is too high, a stand has limited resistance to mountain pine beetle attack. If relative density is too low, cone production may be insufficient to support the Clark's nutcracker on which natural regeneration depends. And finally, any thinning must be done so as to not compromise existing genetic resistance to white pine blister rust.

Generalists like limber pine may be increasingly important as managers are challenged to build resistance and resilience to future conditions in western forests. Additional research is needed to understand how different silvicultural systems can be used to maintain multi-species forest communities.

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CONTACT INFORMATION

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