Monitoring Limber Pine Health in the Rocky Mountains and North Dakota

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Abstract—Ecological impacts are occurring as white pine blister rust spreads and intensifies through ecologically and culturally important limber pine ecosystems of the Rocky Mountains and surrounding areas. The imminent threat of mountain pine beetle has heightened concerns. Therefore, information on the health status of limber pine is needed to facilitate management and restoration efforts. The objectives of this study were to: (1) evaluate the health of limber pine in Colorado, Wyoming, Montana, and North Dakota, (2) establish monitoring plots to assess cumulative ecological impacts of blister rust and other damaging agents over time, and (3) gather baseline information needed to sustain, protect, and restore impacted stands. Eighty-three long-term monitoring plots were established in limber pine stands in 2006 and 2007. Most surveyed limber pines were classified as healthy (74 percent), while 19 percent were declining or dying, and 7 percent were dead. White pine blister rust and twig beetles were the most common damages observed. Evidence of recent mountain pine beetle activity was observed in 19 percent of all plots but mortality levels were low. Average plot incidence of white pine blister rust was greatest in the north and decreased southward except in ND where the disease was not detected. Limber pine regeneration was present in most plots but levels of blister rust infection on regeneration were fairly low. Mountain pine beetle populations have increased substantially since this study was initiated. Since blister rust rapidly kills young trees and bark beetles kill mature trees, their combined impacts could be significant.

Introduction

Limber pine (*Pinus flexilis* James) is an ecologically and culturally important, yet little studied, tree species within the western United States. Its distribution extends from Alberta and southeastern British Columbia to New Mexico, Arizona, and southeastern California with isolated populations in North Dakota, South Dakota, Nebraska, eastern Oregon, and southwestern California (Burns and Honkala 1990). Limber pine has a very wide elevational distribution, ranging from 2,850 feet in North Dakota to 12,500 feet in Colorado (Burns and Honkala 1990). Limber pines serve many important ecological functions such as providing food for wildlife, stabilizing slopes, regulating snow retention and runoff, and maintaining cover on harsh, rugged sites where little else can grow (Schoettle 2004). However, recent reports suggest significant ecological impacts to the species as the result of white pine blister rust (*Cronartium ribicola* J. C. Fisch. ex Rabenh.), mountain pine beetle (*Dendroctonus ponderosae* Hopkins), and other damaging agents (Blodgett and others 2005, Gibson and others 2008, Kearns and Jacobi 2007). Information on the status of limber pine and the long-term ecological impacts of this disease is needed to facilitate management and restoration efforts. The objectives of this study were to (1) assess the current ecological impacts of white pine blister rust on limber pine, (2) establish plots for future re-measurement to assess long-term and cumulative ecological impacts, and (3) gather baseline information needed to sustain, protect, and restore impacted stands.

Methods

Long-term monitoring plots were established in 2006 and 2007 in four study areas (1) northern Colorado and southern Wyoming (COWY), (2) northern Wyoming (NWY), (3) central Montana (MT), and (4) southwestern North Dakota (ND) (fig. 1). Plots were located by systematically selecting stands with a high limber pine component (20 percent or greater) based on vegetation layers, previous surveys, and suggestions from local land managers. Survey methods were adapted from the Whitebark Pine Ecosystem Foundation (Tomback and others 2004). Plots were 200 feet by 50 feet and were divided into three sections with a fixed area circular regeneration and understory vegetation subplot (1/100 acre, 11.8-foot radius) at the center point of each section.

Plot data collected included elevation, slope, aspect, slope position, stand structure, predominant understory species, and disturbance history. Tree data recorded for all trees greater than 4.5 feet tall included species, health status (healthy, less than 5% of crown damaged; declining 6 percent to 50 percent of crown dead or exhibiting symptoms indicating it is dying; dying, >50 percent of crown dead or dying; recent dead, some red needles and fine twigs intact; old dead, no needles or fine twigs intact), diameter at breast (d.b.h.), height, and size class (small: >0-2 in d.b.h.; medium >2-8 in d.b.h.; large: >8 in d.b.h.). Additionally, crown class, crown ratio, percent canopy kill (topkill), and damages and their severities were recorded for all white pines with the exception of those classified as old dead.

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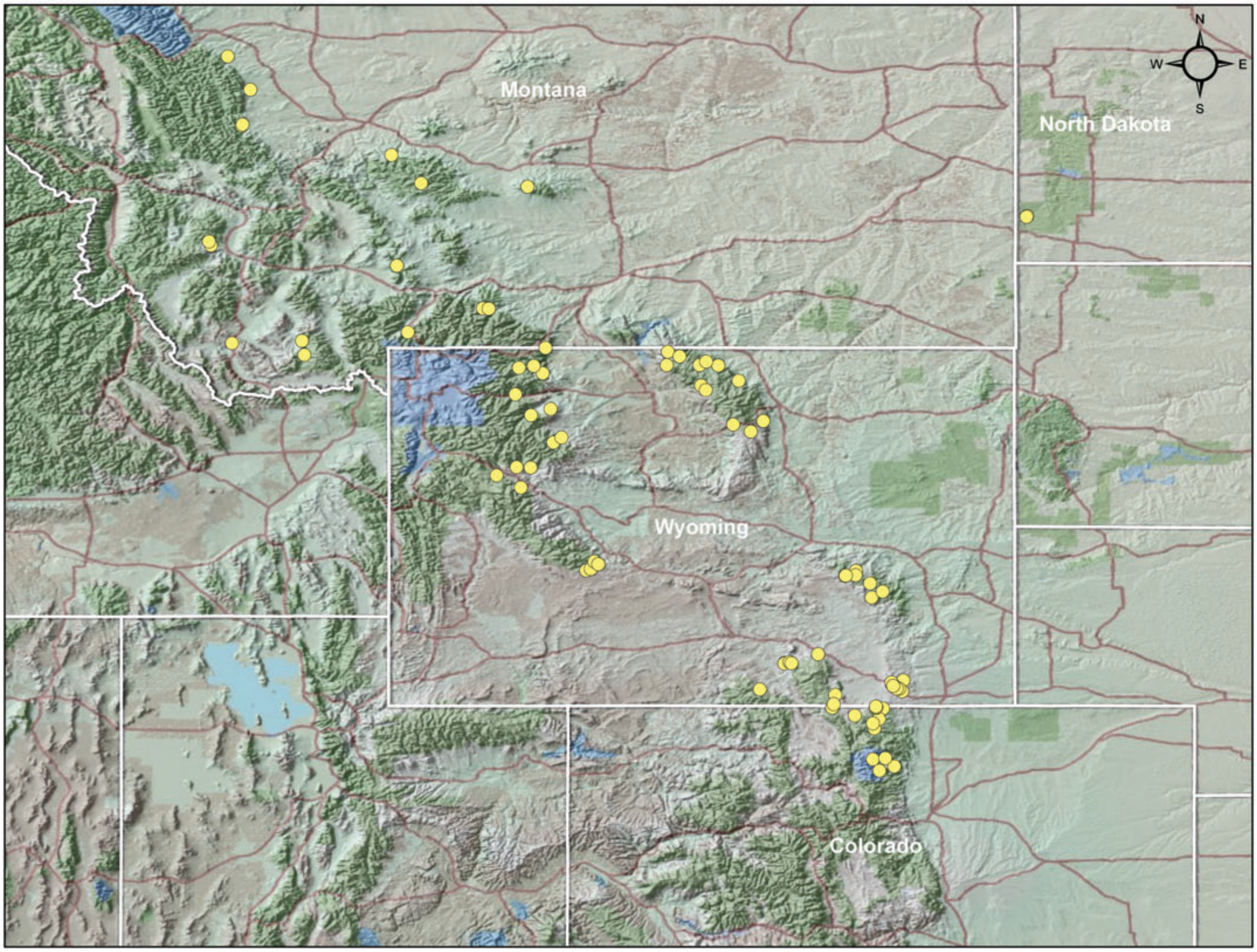

Figure 1. Limber pine monitoring plots (yellow dots) in Colorado, Wyoming, Montana, and North Dakota.

Blister rust disease severity was calculated for all white pines based on cumulative crown and stem damage (Six and Newcomb 2005). This included recording the number of branch cankers per crown third and stem cankers per stem third, and canker lengths. The total score for a tree can range from 0 (no infection) to 18 (all branches and stem infected), with scores from 1 to 4 associated with low severity, 5 to 8 with moderate severity, and over 8 with severe damage.

In subplots, all regeneration (trees less than 4.5 ft tall) was tallied and blister rust infection was recorded for white pine species. Percent and type of ground cover and *Ribes* species was estimated within each subplot.

Results and Discussion

Eighty-three long-term monitoring plots were established (36 in COWY, 29 in NWY, 16 in MT, and 2 in ND) (figure 1). Monitoring plots ranged in elevation from 2,900 to 10,243 feet and were located on a variety of aspects, slopes, and slope positions. On average, 40 limber pines were sampled per plot (range 9 – 180). Across all plots, limber pine density ranged from 39 to 783 trees per acre.

A total of 6,533 trees greater than 4.5 feet tall were assessed in all study areas combined. This included 3,296 limber pine and 22 whitebark pine. Most of the limber pines surveyed were classified as healthy (74 percent), 15 percent were declining, 4 percent were dying, 2 percent were recently killed, and 5 percent were old dead (table 1). White pine blister rust and twig beetles were the most common damages observed, although twig beetle damage severity was generally low. Fifty-three percent of declining and dying trees were infected with white pine blister rust and 51 percent had twig beetle damage. Evidence of bark beetles, including mountain pine beetle, *Ips* engravers, and others was identified on 43 percent of all recently killed trees but this represented only 2 percent of all white pines surveyed. Other less common damages included limber pine dwarf mistletoe (*Arceuthobium cyanocarpum* (A. Nels. ex Rydb.) A. Nels.), other canker diseases, and porcupine damage.

The average incidence of white pine blister rust over all plots was 29 percent (30 percent in COWY, 38 percent in NWY, 49 percent in MT, and 0 percent in ND plots). Based on Six and Newcomb (2005), disease severity is currently low in all areas (table 2). Average disease severity for all plots with

Table 1. Limber pine by health status and percent impacted by white pine blister rust (WPBR), twig beetles, and bark beetles in northern Colorado and southern Wyoming (COWY), northern Wyoming (NWY), Montana (MT), and North Dakota (ND) study areas.

		Healthy[a]			Declining/dying[b]			Recent dead[c]			Old dead[d]
Study Area	Total N	Count	WPBR %	Twig beetles %	Count	WPBR %	Twig beetles %	Count	WPBR %	Bark beetles[e] %	Count
COWY	1434	1217	24	12	155	56	21	32	3	19	30
NWY	1081	884	33	61	84	39	76	17	0	71	96
MT	661	303	36	49	312	69	63	23	57	57	23
ND	120	17	0	6	77	0	38	0	na	na	26
Total/means	3296	2421	29	34	628	53	51	72	19	43	175

[a] <5 % visual damage to crown or stem.
[b] 6-50 % (declining) or >50 % (dying) of the crown showing symptoms that indicated it is dead or will be.
[c] No green needles, red needles and fine twigs present.
[d] Damages were not recorded on the 175 trees classified as old dead.

Table 2. Mean incidence and severity of white pine blister rust in northern Colorado and southern Wyoming (COWY), northern Wyoming (NWY), Montana (MT), and North Dakota (ND) study areas.

	All plots			Plots with WPBR				
Study Area	N	Incidence[a]	S.D.[b]	N	Incidence	S.D.	Severity[c]	S.D.
COWY	36	30	28	29	37	27	1.1	1.1
NWY	29	38	30	25	44	28	1.1	1.1
MT	16	49	35	13	61	27	2.3	1.2
ND	2	0	0	0	*na*	*na*	*na*	*na*
Total/means	83	29	21	67	47	12	1.3	1.2

[a] The number of infected limber pines / the number of evaluated limber pines. Living trees only.
[b] Standard deviation.
[c] White pine blister rust (WPBR) disease severity was calculated for all white pines based on cumulative crown and stem damage (Six and Newcomb 2005). The total score for a tree can range from 0 (no infection) to 18 (total infection), with scores from 1 to 4 associated with low severity, 5 to 8 with moderate severity, and over 8 with severe damage.

infected trees was 1.3 and ranged from 0.1 to 3.9 (SD: 1.2; 95% CI: 1.0-1.6).

White pine blister rust occurred more frequently on medium and large trees than on small trees (table 3). Large trees had a greater number of total infections, but the incidence of stem cankers was highest (66 percent) in small trees and lowest (25 percent) in large trees. Fourteen percent of all infected trees had stem cankers in the bottom third of the crown, 22 percent had stem cankers in the middle third of the crown, and 26 percent had stem cankers in the top third of the crown. The incidence of basal stem cankers was greatest (24 percent) in small trees and least (2 percent) in large trees. Branch cankers occurred throughout the crown in all size classes in all areas.

Limber pine regeneration (trees < 4.5 ft tall) was present in 60 percent of all plots with an average density of 95 trees per acre (range 0-1000 trees per acre). White pine blister rust was detected on regeneration in 7 percent of all plots. The average incidence of white pine blister rust in regeneration plots where limber pine occurred was 3 percent (range 0-75 percent).

Table 3. Proportion of living limber pine trees infected with white pine blister rust (WPBR), mean number of WPBR cankers per infected limber pine, and proportion of infected trees with stem cankers by size class.

				Total Cankers[a]			
Size class	Total N	WPBR Count	%	Mean	Range	S.D.	Proportion of infected trees with stem cankers
Small[a]	830	201	24	2.6	1-13	2.2	66
Medium[b]	1630	617	38	3.9	1-43	4.4	47
Large[c]	589	211	36	7.0	1-48	8.6	25

[a] Mean number of branch and stem cankers per infected limber pine.
[b] >0-2 in d.b.h.
[c] >2-8 in d.b.h.
[d] > 8 in d.b.h.

Conclusions

White pine blister rust is well established in all of the study areas except North Dakota, and results suggest the disease is a major damaging agent in limber pine of the Rocky Mountains. This study provides baseline information on limber pine health. Long-term monitoring of these sites will provide critical information to guide future management and restoration. Although blister rust severity was low in all study areas based on the Six and Newcomb (2005) rating system, our results suggest that ecological impacts are occurring. Blister rust damage was observed on most declining and dying trees, and small trees had a higher frequency of severe infections, suggesting that mortality of small trees is occurring and can be expected to continue. Impacts to medium and large trees are evident as well. Unlike western white (*Pinus monticola* Dougl. ex D. Don) and sugar pine (*Pinus lambertiana* Dougl.), which are infected near the ground where the microclimate is more favorable for infection, infections in limber pine occur throughout the crown (Kearns 2005). Although medium and large trees have fewer severe infections, they have more total infections; this may eventually impact cone production and regeneration potential.

The incidence of blister rust on regeneration (trees < 4.5 ft tall) was low, but it is possible that very small trees are quickly killed and therefore not adequately represented in surveys of this kind. A more thorough examination of limber pine regeneration and the implications of blister rust is warranted.

Mountain pine beetle was present in all study areas except ND but at the time of the survey mortality was minimal. Beetle activity has increased substantially and it is predicted that most mature limber pines are threatened. The combined impacts of mountain pine beetle and white pine blister rust could be devastating in some areas since mountain pine beetles kill mature trees and young trees are especially susceptible to rust. Continued monitoring of limber pine health in the Rocky Mountains will be critical for assessing impacts of these two threats.

Acknowledgments

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