Chapter 18. Monitoring Limber Pine Health in the Rocky Mountains and North Dakota

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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 Colombia 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 as well, 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). They are some of the oldest and largest pines in the Rocky Mountains and are especially valued because of their unique cultural and ecological characteristics. However, recent reports suggest that they are experiencing significant ecological impacts as the result of the exotic invasive disease white pine blister rust (*Cronartium ribicola* J. C. Fisch. *ex* Rabenh.) and other damaging agents (Blodgett and others 2005, Kearns and Jacobi 2007). Information on the status of limber pines 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 within white pine blister rust-infested and threatened areas of the Rocky Mountains and a small outlying population in North Dakota, (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 (2006), (2) northern Wyoming (2007), (3) central Montana (2007), and (4) southwestern North Dakota (2007) (fig. 18.1). 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. Plot locations were stratified by elevation and white pine blister rust intensity (if information was present) and were widely distributed to cover a range of stand and site conditions.

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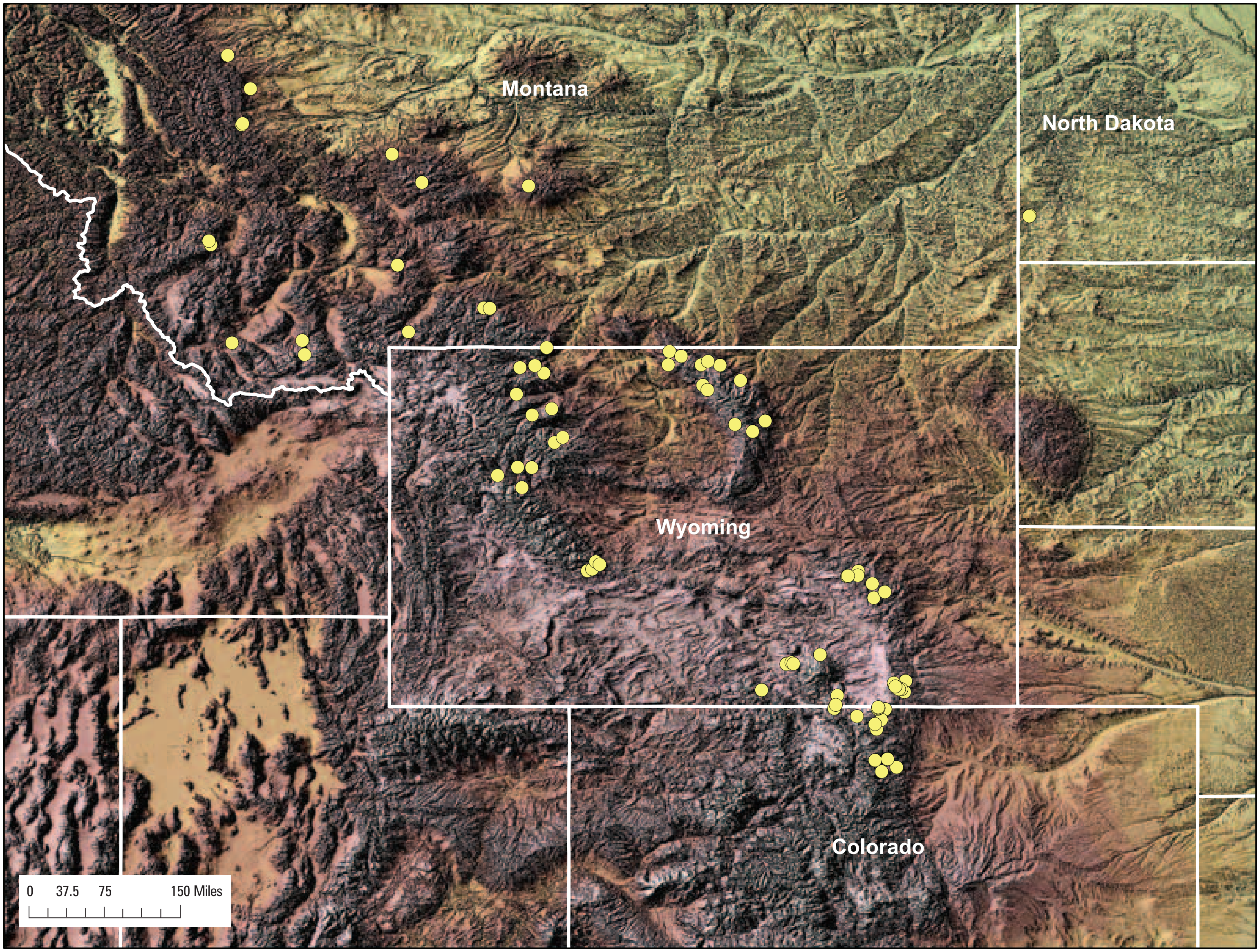

Figure 18.1—Limber pine monitoring plots (yellow dots) in Colorado, Wyoming, Montana, and North Dakota.

Plots in northern Colorado and southern Wyoming (COWY) are located within the Roosevelt and Medicine Bow National Forests and Rocky Mountain National Park. Plots in northern Wyoming (NWY) are on the Bighorn and Shoshone National Forests. Montana (MT) plots are located on lands administered by national forests (Custer, Lewis and Clark, Deer Lodge), the Blackfeet Indian Reservation, The Nature Conservancy, and Montana Department of Natural Resources and Conservation. North Dakota (ND) plots are on the Little Missouri National Grassland.

Monitoring plots were established as belt transect plots using methods adapted from the Whitebark Pine Ecosystem Foundation (Tomback and others 2004) and Six and Newcomb (2005). Plots (200 feet by 50 feet) were divided into three sections (fig. 18.2) with a fixed area circular regeneration and understory vegetation subplot (1/100 acre, 11.8-foot radius) at the center point of each section. The three sections provided stand density and species composition information associated with each regeneration plot. Plots were monumented with a labeled rebar stake at the center point of the beginning and end; GPS coordinates were collected at these points as well.

Transect-level data collected included transect bearing, elevation, slope, aspect, slope position,

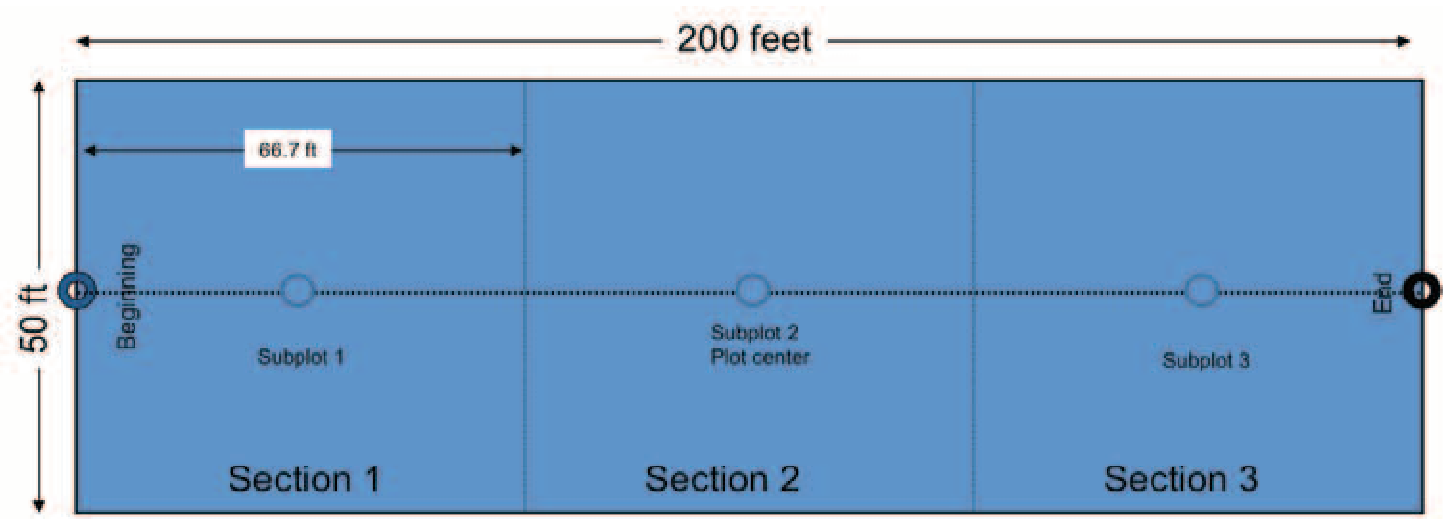

Figure 18.2—Diagram of plot layout.

stand structure, and disturbance history. The three most common shrub species within each section were listed by genus and species.

Data recorded for all trees greater than 4.5 feet tall[9] (1.4 m) included tree tag number*, stem clump number, section number*, species*, health status*, d.b.h.*, height*, size class* (small: > 0–2 inches d.b.h.; medium > 2–8 inches d.b.h.; large: > 8 inches d.b.h.), height to lowest live branch with needles within 1 foot of stem, crown class, crown ratio, percent canopy kill (topkill), and all damages and their severities impacting more than 5 percent of the tree. Needle retention was recorded for three limber pine trees per section (nine per plot) that were average tree height and (ideally) single stemmed. Whorls were counted back from branch tip and average foliated length was recorded for each branch.

For white pines, stem damage associated with blister rust was quantified by dividing the stem into thirds and recording stem condition (no blister rust stem infections, 1 to 25 percent infected, 25 to 50 percent infected, and > 50 percent infected) and the number of stem cankers (cankers on the main stem or within 6 inches of the main stem) for each third. Similarly, crown damage was quantified by dividing the crown into thirds horizontally and recording crown condition (no visible blister rust branch infections, < 25 percent branches infected, 25 to 50 percent branches infected, > 50 percent branches infected), number of branch cankers, canker lengths (only on live branches), and percent of outer branch tips with fresh green cones for each third. White pine blister rust disease severity was calculated for each tree based on cumulative crown and stem damage (Six and Newcomb 2005).

In subplots, all regeneration (trees < 4.5 feet tall), regardless of species, were tallied by species and height class (0-10 inches or 10-54 inches) and blister rust infection was recorded for white pine species. Percent ground cover of litter, rock, bare soil, tree stems, shrubs, and forbs was estimated within each subplot, as was percent cover of *Ribes* species.

Results and Discussion

A total of 83 long-term monitoring plots were established including 36 in COWY, 29 in NWY, 16 in MT, and 2 in ND (fig. 18.1). The limber pine population in North Dakota is very small and isolated (Potter and Green 1964) and so was fairly adequately surveyed with a small sample size. 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). A variety of stand compositions and structures were represented, ranging from open savannahs to mixed conifer forests. On 13 percent of plots, limber pine was the only species present. Across all plots, limber pine density ranged from 39 to 783 trees per acre.

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[9] Variables with an asterisk were collected for all species. All variables were recorded for white pine species.

Other species that were frequently associated with limber pine included juniper (NWY, MT, and ND), Douglas-fir (COWY, NWY, MT), lodgepole pine (COWY), aspen (COWY), and ponderosa pine (COWY). The only other white pine species encountered was whitebark pine, which was present in 2 plots within the MT study area.

A total of 6,533 trees were sampled in all of the study areas combined. This included 3,293 limber pines and 22 whitebark pines. Arithmetic mean diameter of surveyed limber pines was 5.0 inches (range = 0.1 to 46.5 inches d.b.h.) and average height was 16.3 feet (range = 4.5 to 55.0 feet). Most of the limber pines surveyed were classified as healthy (74 percent) while 19 percent were classified as declining or dying, and 7 percent were dead (table 18.1). White pine blister rust and twig beetles were the most common damages observed, although twig beetle damage severity was generally classified as 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 40 percent of all recently killed trees. Other less common damages included limber pine dwarf mistletoe, other canker diseases, and porcupine damage.

The average incidence of white pine blister rust over all plots was 36 percent (30 percent in COWY, 38 percent in NWY, 50 percent in MT, and 0 percent in ND plots). Based on Six and Newcomb (2005), disease severity is currently low in all areas (table 18.2). The total score for

Table 18.1—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			Declining/dying			Recent dead		
Study area	N	Count	WPBR	Twig beetle	Count	WPBR	Twig beetle	Count	WPBR	Bark beetles[a]
			percent	*percent*		*percent*	*percent*		*percent*	*percent*
COWY	1,401	1,216	23	12	153	55	21	32	3	16
NWY	985	884	33	61	84	39	76	17	0	71
MT	638	303	36	49	312	69	63	23	57	57
ND	94	17	0	6	77	0	38	0	0	0
Total	3,293	2,420	28	34	626	53	51	72	19	40

N = number of limber pine trees sampled.
[a] The proportion of limber pines showing evidence of damage caused by mountain pine beetles, *Ips* engraver beetles, or other bark beetles.

Table 18.2—Mean incidence and severity of white pine blister rust (WPBR) 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.	N	Incidence	S.D.	Severity[b]	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	50	36	13	62	29	2.3	1.2
ND	2	0	0	0	NA	NA	NA	NA
Total	83	29	21	67	48	13	1.3	1.2

N = number of limber pine trees sampled.
NA = not applicable.
S.D. = Standard deviation.
[a] Incidence is the number of infected limber pines / the number of evaluated limber pines.
[b] 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.

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. Average disease severity for all plots with infected trees was 1.3 and ranged from 0.1 to 3.9 (SD: 1.2; 95 percent CL: 1.0–1.6).

Most infected limber pines (80 percent) had 10 or fewer branch cankers, but 45 percent of all infected trees had stem cankers (table 18.3). White pine blister rust occurred more frequently on medium (> 2–8 inches d.b.h.) and large (> 8 inches d.b.h.) trees than on small (> 0–2 inches d.b.h.) trees (table 18.3). Large trees had a greater number of total infections but the incidence of stem cankers was highest (65 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 feet tall) was present in 60 percent of all plots with an average density of 95 trees per acre (range 0-1,000 trees per acre). White pine blister rust was detected on regeneration in 7 percent of all

Table 18.3—Proportion of living limber pine trees infected with white pine blister rust (WPBR) by size class, mean number of WPBR cankers per infected limber pine, and proportion of infected trees with stem cankers by size class

		WPBR		Total cankers			Proportion of infected trees with stem cankers
Size class	N	Count	%	Mean	Range	S.D.	
Small	830	201	24	2.6	0-13	2.2	65%
Medium	1,630	617	38	3.9	0-43	4.4	46%
Large	589	211	36	7.0	0-48	8.6	25%
Total	3,049	1,029	34	4.3	0-48	5.5	45%

N = number of limber pine trees sampled.
S.D. = Standard deviation.

plots. The average incidence of white pine blister rust in regeneration plots where limber pine occurred was 3 percent (range 0–75 percent). Limber pine was the most commonly regenerating species followed by aspen, Douglas-fir, and Engelmann spruce. Other less commonly regenerating species included juniper, lodgepole pine, subalpine fir, and whitebark pine.

On average, the percent of limber pine branches with cones was 6.4 percent (range = 0–43 percent). The percent of branches with cones was higher at the top of the tree (12.5 percent) as compared to mid-crown (4.3 percent) and low crown (1.5 percent). Limber pine infected with blister rust had similar amounts of cones as uninfected trees. On plots with a high incidence of rust (> 50 percent of trees infected with white pine blister rust), infected and uninfected trees had on average 6.8 percent and 5.4 percent branches with cones, respectively.

Conclusions

White pine blister rust is well established in all of the study areas except North Dakota, and results from this survey suggest that the disease is a major damaging agent in limber pine in the Rocky Mountains. This study provides baseline information on limber pine health in four study areas within the Rocky Mountains. Long-term monitoring of limber pine at these sites will provide critical information to guide future management and restoration.

Although blister rust severity is currently low in all study areas based on the Six and Newcomb (2005) rating system, results suggest that ecological impacts of white pine blister rust are occurring. Blister rust damage was observed on most declining and dying trees, and small (> 0–2 inches d.b.h.) trees had a higher frequency of severe infections, suggesting that mortality of small trees is occurring and can be expected to continue. Small trees are particularly susceptible to the disease because the distance the fungus needs to travel from foliage, the point where infection occurs, to the main stem is small compared to larger trees, and because small branches and stems are quickly girdled. Impacts to medium (> 2–8 inches d.b.h.) and large (> 8 inches d.b.h.) trees are evident as well. Unlike western white pine and sugar pine, 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 feet tall) currently appears to be low, but it is possible that trees this small 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 and other bark beetles are contributing to mortality in all study areas but at the time of the survey impacts were minimal. Mountain pine beetle activity has since 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 since young trees are especially susceptible to rust. Continued monitoring of limber pine health in the Rocky Mountain region will be critical for assessing impacts of these two threats.

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