Forest Health Protection

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FOREST HEALTH ASSESSMENT OF WHITEBARK PINE IN SELECTED STANDS IN THE SELKIRK MOUNTAINS OF NORTHERN IDAHO 2001

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Introduction

Whitebark pine stands in the Selkirk Mountains, Idaho Panhandle National Forests, have been steadily declining for several years due to white pine blister rust (BR) and mountain pine beetle (MPB). Within the past few years, a MPB outbreak has significantly increased the rate and amount of mortality. Ground surveys conducted in three areas in the fall of 2000 documented a loss of 45-82% of the whitebark pine primarily due to MPB. From 33%-87% of the remaining green trees in those areas had blister rust (BR) symptoms (Kegley et al. 2001). These results prompted a more extensive ground survey in the fall of 2001 to determine whitebark pine conditions in additional stands.

Methods

In August and September 2001, five areas of whitebark pine were examined for MPB attack and BR infection in the Selkirk Mountains, Bonners Ferry Ranger District. These areas were Cutoff Peak, Fisher Peak, Trout Lake, Farnham Ridge, and East Russell Ridge.

Two types of surveys were conducted. On Farnham Ridge and East Russell Ridge, data were recorded from a series of variable radius plots. On Cutoff Peak, Fisher Peak, and Trout Lake, whitebark pine were examined in random strip surveys in addition to variable radius plots because variable radius plots did not include a large enough sample of white bark pine.

Data recorded for each tree included: species, diameter (d.b.h.), and a description of any bark beetle activity or blister rust infection. Bark beetle activity was classified as current, last year, and older MPB attack, or unknown or secondary bark beetle mortality. Partial bole attacks (strip attacks) and unsuccessful attacks (pitchouts) were also recorded. BR data included branch cankers, bole cankers, and percent top kill. Trees with only dead branches were rated as lightly infected; multiple branch cankers or less than 30% top kill were rated as moderately infected; bole cankers or more than 30% top kill were rated as severely infected. Older dead whitebark pine (snags) were not recorded.

In the summers of 2001 and 2002, five Lindgren funnel traps baited with MPB attractants, exobrevicomin and trans-verbenol (Pherotech, Inc.), were hung near the Trout Creek trailhead. Traps were monitored weekly and MPB counted to determine flight periodicity.

Logistic regression was used to explore the relationship between MPB mass attack, d.b.h., and BR condition by area. Pearson’s chi square test was used to determine the probability of MPB attack on trees with or without severe BR.

Results

Stand Characteristics

Stand characteristics for each area including total trees per acre (TPA), basal area (BA), quadratic mean diameter (QMD), and numbers of plots are shown in table 1.

Table 1. Stand characteristics as determined by ground surveys, 2001. (TPA = trees per acre, BA= basal area, QMD = quadratic mean diameter.) The last number in each column is the standard error or variance around the mean (SEM).

Area # of plots	Stand Attribute	**Whitebark Pine**		*SEM*	**Lodgepole Pine**	*SEM*	**Subalpine Fir**	*SEM*	**Spruce**	*SEM*	**Total**	*SEM*
Cutoff Peak	Total TPA	**22**	17%	*7.5*	**23**	*17.1*	**56**	*15.9*	**30**	*11.7*	**131**	*17.8*
	Total BA	**23**	22%	*2.9*	**23**	*15*	**31**	*9.6*	**29**	*7.4*	**106**	*16.2*
	QMD	**16.5**		*2.3*	**14.1**	*4*	**10.0**	*0.7*	**14.4**	*2.0*	**12.1**	*0.4*
7 plots	Live TPA	**8**	8%		**20**	*0*	**47**		**30**		**105**	
	Live BA	**14**	15%		**20**		**29**		**29**		**91**	
Fisher Peak	Total TPA	**108**	78%	*26.6*	0		**24**	*0*	**6**	*0*	**138**	*38.3*
	Total BA	**110**	94%	*24.1*	0		**3**	*0*	**3**	*0*	**117**	*26.5*
	QMD	**13.8**		*1.3*	0		**5.0**	*0*	**10**	*0*	**13.1**	*0.9*
6 plots	Live TPA	**89**	75%		0		**24**		**6**		**119**	
	Live BA	**87**	94%		0		**3**		**3**		**93**	
Trout Lake	Total TPA	**101**	42%	*34.3*	0		**103**	*42.2*	**37**	*17.8*	**240**	*42.8*
	Total BA	**102**	50%	*18.1*	0		**24**	*9.9*	**29**	*9.5*	**156**	*15.6*
	QMD	**15.0**		*2.0*	0		**6.9**	*0.7*	**13.4**	*4.9*	**11.8**	*0.8*
9 plots	Live TPA	**78**	36%		0		**103**		**37**		**218**	
	Live BA	**73**	57%		0		**24**		**29**		**127**	
Farnham Ridge	Total TPA	**89**	42%	*24.6*	**35**	*16.3*	**45**	*15.6*	**41**	*16.2*	**211**	*37.5*
	Total BA	**58**	50%	*11.7*	**25**	*311.8*	**13**	*4.5*	**18**	*5.2*	**115**	*14.4*
	QMD	**13.0**		*1.1*	**11.8**	*4.0*	**7.7**	*1.1*	**10.2**	*1.4*	**10.7**	*0.6*
12 plots	Live TPA	**13**	10%		**33**		**45**		**41**		**133**	
	Live BA	**8**	13%		**23**		**13**		**18**		**63**	
East Russell Ridge	Total TPA	**106**	26%	*15.4*	**26**	*13.4*	**249**	*39.9*	**22**	*8.7*	**404**	*39.2*
	Total BA	**92**	45%	*8.9*	**20**	*7.3*	**74**	*12.5*	**17**	*5.5*	**203**	*13.1*
	QMD	**13.3**		*1.4*	**13.8**	*4.9*	**7.5**	*0.3*	**14.1**	*6.8*	**10.2**	*0.3*
25 plots	Live TPA	**8**	3%		**11**		**249**		**20**		**289**	
	Live BA	**6**	6%		**6**		**74**		**16**		**102**	

The amount of whitebark pine varied widely between the five areas sampled, but was the species with the largest average d.b.h. in all areas. The whitebark pine stand component varied from a high of 94% total BA and 78% total TPA at Fisher Peak to a low of 22% total BA and 17% total TPA at Cutoff Peak. However, amount of remaining live whitebark varied from 75% live TPA (94% live BA) at Fisher Peak to only 3% live TPA (6% live BA) at East Russell Ridge. Fisher Peak was the only area of the five sampled where whitebark pine was still the dominant species. Trout Lake and Russell Ridge are primarily subalpine fir stands while Farnham Ridge and Cuttoff Peak also have major components of Engelmann spruce and lodgepole pine.

Individual stand losses varied considerably. Whitebark pine was originally about half the total BA at Trout Lake, Farnham Ridge and East Russell Ridge but these numbers have declined dramatically at two of the areas. The worst losses occurred on Farnham Ridge where 85% of the whitebark TPA and 86% of the whitebark BA had died and East Russell Ridge where whitebark TPA declined 92% and BA decreased 93%. Lodgepole pine on East Russell Ridge had also been attacked by MPB resulting in a 70% decrease in lodgepole pine BA.

Whitebark Pine Condition

Number, average diameter, and percent of all healthy whitebark pine, those with current, last year, and older MPB attack, unknown or secondary bark beetle mortality, and BR infection are recorded by area in table 2.

East Russell Ridge had extreme whitebark pine mortality; 94% of the whitebark pine sampled were dead. Of those, 63% were killed by MPB from 2000-2001. On Farnham Ridge, 83% of the whitebark pine sampled were dead but most of it was old mortality—only 14% occurred in 2000-2001. However, the sample size may have been too small to adequately represent actual conditions. On Cutoff Peak, 42% of the whitebark pine sampled were dead with most of the mortality occurring in 2000-2001. On Fisher Peak, 29% of the whitebark were dead; most were killed in 2000-2001. Trout Lake had the lowest mortality. There, 17% of the whitebark sampled were dead and only 8% had been killed by MPB in 2000-2001. Unknown or secondary bark beetle mortality was recorded on only a few trees in each area. Very few trees were found with strip attacks or pitchouts. Strip attacks were classified as current MPB attack, and pitchouts were classified as live trees.

In all areas, the average d.b.h. of trees killed by MPB was significantly higher than unattacked trees (table 2), and the probability of successful MPB attack increased with increasing tree d.b.h. ($p<.02$).

BR infection varied from 57% on Farnham Ridge to 81% at Cutoff Peak. However, rust infection may have been underestimated since small BR infections are very difficult see, especially in dense crowns or on dead trees. We were most confident in identifying trees with severe rust infections, so we were most interested in further analyses aimed at describing interactions between MPB and severely BR infected trees.

Aerial survey data indicate that whitebark pine mortality due to MPB is expanding and intensifying (more trees killed per acre) in the Selkirk Mountains (fig. 1). Aerial surveys record faded trees that were actually attacked and killed the previous year. In 2000, surveys recorded 9,273 faded whitebark on 8,634 acres. By 2002, tree mortality had increased to 40,798 faded whitebark on 12,786 acres. In 2003, recorded mortality was nearly the same with 38,732 trees killed on 12,735 acres.

Table 2. Whitebark pine with MPB or BR infection by area.

Location	Cutoff Peak	Fisher Peak	Trout Lake	Farnham Ridge	East Russell Ridge
# WBP examined	202	139	200	35	117
Ave. d.b.h.	16.3	14.2	16.9	12.9	14.3
WBP alive	118 (58%)	99 (71%)	167 (84%)	6 (17%)	7 (6%)
Year 2001 MPB attack	21 (10%)	17 (12%)	11 (6%)	3 (9%)	24 (21%)
Year 2000 MPB attack	32 (16%)	14 (10%)	4 (2%)	2 (6%)	50 (43%)
Older MPB attack	24 (12%)	6 (4%)	13 (7%)	19 (54%)	30 (26%)
Ave d.b.h. with MPB	17.7	14.9	20.0	14.1	14.5
Ave d.b.h. no MPB	15.3	13.9	16.4	10.1	12.7
Unknown or secondary mortality	7 (3%)	3 (2%)	5 (3%)	5 (14%)	6 (5%)
Total Dead	84 (42%)	40 (29%)	33 (17%)	29 (83%)	110 (94%)
WBP killed by MPB in 2000-2001	53 (26%)	31 (22%)	15 (8%)	5 (14%)	74 (63%)
WBP infected with BR	164 (81%)	90 (65%)	134 (67%)	20 (57%)	78 (67%)

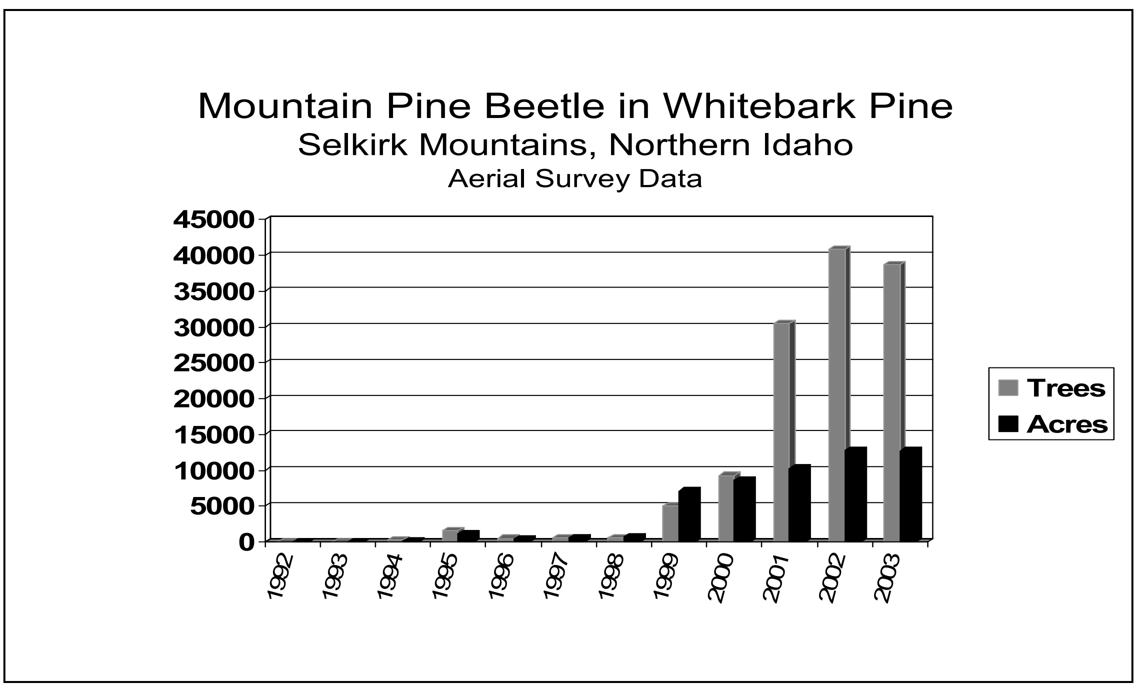

Figure 1. Whitebark pine mortality due to MPB in the Selkirk Mountains from 1992-2002 as recorded by aerial surveys.

Blister Rust and Mountain Pine Beetle Interactions

Since it is difficult to determine uninfected trees from lightly or even moderately infected trees, we focused our analyses on comparing MPB success in trees with severe rust infections to trees with moderate, light or no infection observed. Our logic was that MPB might detect severely infected trees due to slower growth rate, but might not detect differences between uninfected trees and those with only a few dead branches or branch cankers.

When data from all areas are pooled, we found MPB preferred trees that were not severely infected with blister rust ($p<.035$) (table 3). Only 35% of trees with severe BR had successful MPB attacks while 43% of trees without severe blister rust had successful MPB attacks.

Table 3. Interactions between successful mountain pine beetle attacks and severe blister rust infections on whitebark pine

	No MPB	MPB	Total
Severe BR	209 (65%)	111 (35%)	320
Not Severe BR	214 (57%)	159 (43%)	373
Total	423	270	693

However, this effect was not uniform across all areas. The proportion of whitebark severely infected with blister rust varied from 17% at Farnham Ridge, which had the lowest total rust infection to 58% at Cuttoff Peak, which had the highest total rust infection (table 4). MPB-caused mortality in whitebark ranged from 14% at Trout Lake to 89% at East Russell Ridge.

At Fisher Peak and Trout Lake, where nearly half the whitebark were severely infected with BR and MPB populations were the lowest, MPB seemed to prefer severely infected trees (33.8% vs. 19.7% and 15.6% vs. 12.7% respectively). Cuttoff Peak had more severely BR infected trees and a higher MPB population, but the most successful MPB attacks were on trees that were not severely infected with BR (44% vs. 33.9%). MPB was also most successful in trees without severe BR at Farnham Ridge and Russell Ridge, which had the highest proportion of MPB attacks and the lowest proportion of severely infected BR trees.

Table 4. Interactions between successful mountain pine beetle attacks and severe blister rust infections on Whitebark pine (WBP) sampled in each area

Location	Cutoff Peak	Fisher Peak	Trout Lake	Farnham Ridge	East Russell Ridge
# WBP examined	202	139	200	35	117
Severe BR No MPB	78	45	76	4	6
Severe BR + MPB	40	23	14	2	32
% MPB in Severe BR	33.9%	33.8%	15.6%	33.3%	84.2%
MPB + not severe BR	37	14	14	22	72
No MPB + Not Sev. BR	47	57	96	7	7
% MPB in not Severe BR	44%	19.7%	12.7%	75.9%	91.1%
Total Sev BR	118 (58%)	68 (49%)	90 (45%)	6 (17%)	38 (32%)
Total MPB	77 (38%)	37 (27%)	28 (14%)	24 (68%)	104 (89%)

Flight Monitoring

In 2001, flight-monitoring traps were placed near beetle-infested whitebark pine stands on May 30 and monitored weekly except for a period of 2 weeks in August. We observed new attacks in whitebark pine trees on May 29 that had been strip attacked the previous year. We caught MPB on June 9, the first time trap catches were collected, through September 18 when traps were removed. There appeared to be two peaks during the MPB summer flight—one occurring in early July, the other sometime in August (fig. 2).

In 2002, we placed flight-monitoring traps in the same location on June 6. Beetles were caught from then through September 20. Traps were removed September 25. Once again, there appeared to be two peaks in the flight—one in late June to mid-July, the other in mid- to late August (fig. 3). The troughs between the peaks were periods of cool, or cool and wet weather.

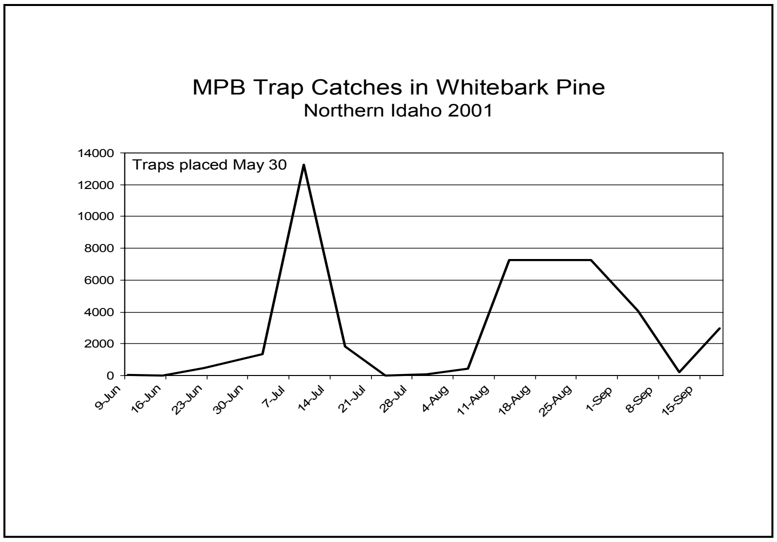

Figure 2. MPB flight period in whitebark pine, summer 2001. Trap catches were not collected August 11 or 18, therefore beetles collected August 25 were averaged over the 3-week period.

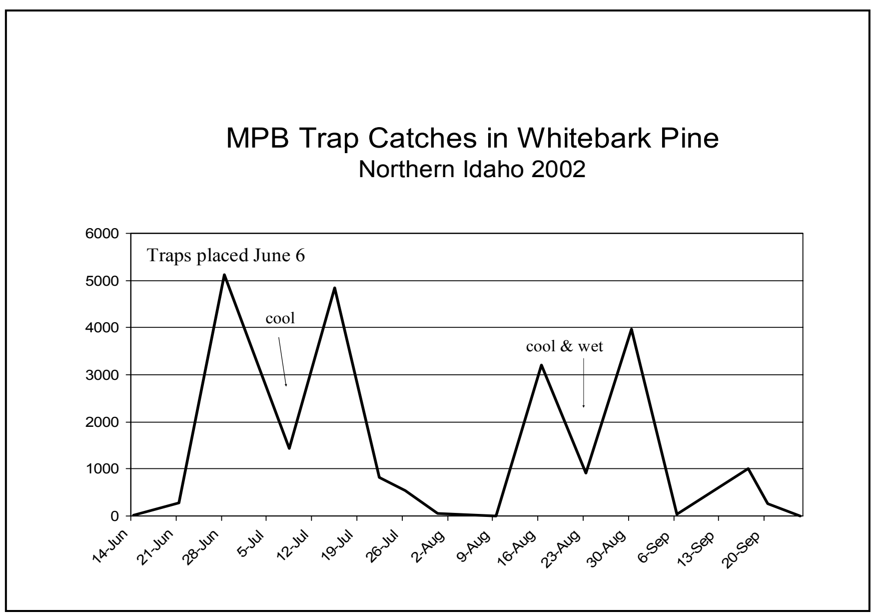

Figure 3. Mountain pine beetle flight period in whitebark pine, summer 2002.

Discussion

To date, MPB populations are still active in the Selkirk Mountains of northern Idaho. In some areas, few live mature whitebark pines remain. In other areas, MPB populations are not as high and beetle-caused mortality has not been as extreme. However, we expect mortality due to MPB to continue for the next few years. Walk-through examinations of trees near Trout Lake in October 2002 discovered many green trees had been attacked by MPB. Those were recorded as faders in 2003.

Flight period of MPB in whitebark pine appears to be longer than in lodgepole pine. In lodgepole pine, the major flight generally occurs in July and August (Amman & Cole 1983). Normally, MPB could take 2 years to complete their development at the high elevations where whitebark pine occurs (Amman & Cole 1983). Because we have had warm, dry weather well into the fall for the past few years, it is possible that the life cycle has been shortened to something less than 2 years. Our winters have also been relatively mild for the past few years, which may have allowed MPB life stages not normally cold-hardy to survive the winter. Population sampling in the fall revealed eggs, larvae, pupae and adults under the bark of dying trees. Normally, and in most MPB hosts, only larvae survive the winter (Amman & Cole 1983). The two peaks in the flight period both years could be two univoltine populations emerging at different times. It is also possible the first peak is the major flight and the second peak is adults re-emerging from initially attacked trees to attack additional trees. This is known to occur in lodgepole pine (Barbara Bentz, personal communication). Additional studies are needed to determine the life cycle of MPB in whitebark pine. Many more beetles were caught in 2001 than in 2002. This may have been because few live host trees were left in the vicinity of the traps in 2002.

There was a strong relationship between MPB attacks and tree d.b.h. in all areas. Average d.b.h. of MPB attacked trees was higher than unattacked trees and probability of attack increased with increasing d.b.h. This relationship has been well documented in lodgepole pine (Cole and Amman 1980, Safranyik et al. 1982) but only suspected in whitebark pine.

Results from these surveys seem to indicate MPB generally favor trees that are not severely infected with blister rust ($p < .035$), although this pattern was not consistent across all five areas. Cutoff Peak, Farnham Ridge, and East Russell Ridge where the MPB populations were the highest followed this pattern. In a previous survey at nearby Pyramid Lake where MPB populations were high, we found MPB attacking more trees without obvious BR signs than with some level of BR (Kegley et al. 2003). Although analyses in this area were not restricted to severely infected trees, MPB seemed to prefer trees without BR.

However, results from Fisher Peak and Trout Lake, which had the lowest MPB populations, indicated MPB preferred severely BR infected trees. This agrees with surveys at two sites in Montana, where low MPB populations preferred whitebark pine with higher BR infection levels (Adams and Six 2002). Therefore, it appears that at low population levels, MPB may select BR weakened trees but as MPB populations increase, attacks become more random.

The mixed results from all these studies may be due partially to the difficulty in accurately assessing BR infection levels on mature trees. Therefore, perhaps we should focus our analysis on severely infected trees. It seems unlikely MPB could detect differences between trees with light BR infections and those without any infection anyway. We also believed severely infected trees would more likely affect MPB behavior, and we are much more confident in accurately diagnosing trees with severe BR infections.

Sample sizes of MPB-infested trees and ones severely infected with BR were fairly small in this study. Larger samples might help clarify relationships between MPB and BR. Because d.b.h. is an important factor in MPB attack, it must be taken into account in statistical analyses to prevent clouding possible relationships with severity of rust infection.

We plan to continue monitoring Fisher Peak and Trout Lake stands that had low MPB activity. We hope to document any apparent changes in the BR/MPB relationship as MPB populations increase.

Acknowledgements

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