INSECTS OF WHITEBARK PINE WITH EMPHASIS ON MOUNTAIN PINE BEETLE

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ABSTRACT

*Few insects that live on whitebark pine (*Pinus albicaulis*) are considered pests or potential pests. Those that inhabit cones can cause reductions in reproduction of the tree by destroying seed crops. Decreases in food for animals ranging from squirrels to grizzly bears may also result.*

*A single insect species, mountain pine beetle (*Dendroctonus ponderosae*) (MPB), may cause serious damage to whitebark pine over much of its range by killing mature trees. Through periodic epidemic outbreaks, the resultant tree killing causes reductions in seed cones and so decreases food supplies for various animals. Excessive mortality of whitebark pine can lead to increases in other tree species, and decreases in whitebark pine, in some future stands.*

A survey of MPB damage in the whitebark pine zone was conducted in Yellowstone National Park, Gallatin National Forest, and Flathead National Forest from 1983 to 1988. Preliminary results show 22 to 44 percent of the whitebark pine had been killed by MPB during the recent past. Losses were strongly related to elevation—decreasing mortality with increasing elevation. Losses were heaviest in the lodgepole pine-whitebark pine ecotone. Implications of such losses are discussed.

INTRODUCTION

Whitebark pine (*Pinus albicaulis* Engelm.) occurs at high elevations in the mountainous west of North America (Arno and Hoff 1989). This is a long-lived tree that grows very slowly on moist to dry sites. Like other trees, the whitebark pine provides habitat for various insect species. Most of these insects do not have serious effects on whitebark pine. An exception is mountain pine beetle (MPB) (*Dendroctonus ponderosae* Hopkins [Coleoptera: Scolytidae]) which occasionally occurs in epidemic proportions. Insects associated with whitebark pine have not been studied in any detail and, therefore, revelant literature is quite sparse.

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Seeds from whitebark pine are not only important for regeneration of the trees but are also important as a food source for various animals (grizzly bears to squirrels). Whitebark pine cones can be invaded by cone worms (*Dioryctria* spp. and *Eucosma* spp.) and by cone beetles (*Conophthorus* spp.), but these insects have been virtually unstudied. Other species than those reported in the literature have been observed (Dewey 1989), such as midges and a seed chalcid (*Megastigmus* spp.). Cone and seed insects would probably affect whitebark pine as they do other conifer species, for example, causing years of light cone crops following a heavy cone crop year. More detailed work on cone and seed insects would show their importance to the whitebark pine system.

Foliage insects can cause stress in attacked trees by causing a decline in their growth rate. Aphids (*Essigella gillettei* Hottes) are known to feed on needles; mealybugs (*Puto cupressi* Coleman and *P. pricei* McKenzie) are found on branches and trunks (Arno and Hoff 1989). Arno and Hoff (1989) also state that the lodgepole needletier (*Argyrotaenia tabulana* Freeman), which is very destructive in lodgepole pine stands, can also infest whitebark pine.

Several secondary beetles (*Ips*, *Pityogenes*, and *Pityophthorus*) are known to attack the boles of whitebark pine. The Monterey pine ips (*Ips mexicanus* Hopkins) and two Pityogenes (*P. carinulatus* LeConte and *P. fossifrons* LeConte) are reported to infest the bole of whitebark pine (Furniss and Carolin 1977). Bright (1968) working in British Columbia described two species of *Pityophthorus* (*P. aquilonius* Bright and *P. collinus* Bright) that are found in whitebark pine.

Mountain pine beetle is the most destructive bark beetle in western North America (Furniss and Carolin 1977) because it can kill apparently healthy trees. This is the one insect that has the most impact on whitebark pines. Between 1911 and 1942 there was widespread destruction of lodgepole pine (*Pinus contorta* Douglas) forests by MPB in Idaho and Montana. These outbreaks were at lower elevations and moved upwards into the whitebark pine zone where "ghostlike forests" were created by the numerous dead snags that resulted (Ciesla and Furniss 1975) in about 1937. A similar situation occurred on the Flathead National Forest (NF) of Montana in the 1970's where epidemics developed in the lodgepole pine forests and then moved into the whitebark pine zone (Arno and Hoff 1989).

There are several instances of whitebark pine being invaded by MPB from epidemic populations that occur in lower elevation lodgepole pine. Baker and others (1971) conducted a study in western Wyoming to see if this scenario held true. In situations where both lodgepole and whitebark pine existed together, MPB killed proportionally more lodgepole than whitebark pine. In part, Baker and others (1971) attributed this to phloem thickness with the larger diameter trees (those with thicker phloem) being taken. Another part of their study described how cooler temperatures at the higher elevations caused little mortality by MPB in either lodgepole or whitebark pine. In part, the colder temperatures at the higher elevations reduced MPB survival and therefore lessened the number of trees killed.

Crossover of MPB from one host species to another has been detailed by Amman (1982). It is generally believed that insects invade species similar to the ones in which they developed (Allee and others 1949). However, both Amman (1982) and Wood (1963) stated that this rule probably holds under endemic (low population levels) situations only; during "full blown" epidemics MPB will select any acceptable host. Thus, we observe the movement of MPB from lodgepole into whitebark pine in the ecotonal zone with further movement into pure whitebark pine stands when epidemic conditions exist throughout vast lodgepole pine stands at lower elevations (Parker 1973).

As just described, a variety of insects occur in whitebark pine; however, none have the impact that MPB does. Therefore, it is the purpose of this paper to detail the effect of MPB on whitebark pine with particular emphasis on the northern Rocky Mountain region. Recent past epidemics and current work will be used to complete the picture of the effect of MPB on the whitebark pine ecosystem.

RECENT HISTORY

To better understand the interrelationship of MPB and whitebark pine we can look at the infested acres in the Northern Region of the USDA Forest Service during the past 10 years. Particular interest will be placed on the Gallatin and Flathead National Forests and surrounding areas.

Infested areas were determined by using aerial sketch mapping. Usually, this method does not record low level (endemic) populations of MPB. Mountain pine beetle activity peaked in the Northern Region during 1981. The following acreage was reported as infested lodgepole pine (predominantly lodgepole pine but other species did occur): Gallatin National Forest, 455,000 acres; Beaverhead National Forest, 119,000 acres; Flathead National Forest, 209,000 acres; and Yellowstone National Park, 965,000 acres.

Our reference to whitebark pine stands means that whitebark pine does occur but is not necessarily the dominant species. There were 32,000 acres of whitebark pine infested with MPB in 1983 in the Gallatin National Forest. This acreage has declined precipitously with only 500 acres infested in 1986 and none since then. The MPB epidemic has probably "run its course" in this area.

Similar trends were observed on other areas adjacent to the Gallatin National Forest. At the turn of the decade, there were about 10,000 acres of MPB-infested whitebark pine reported for the Beaverhead National Forest; during the past several years no additional infested acreage was reported. A similar trend was observed on the Custer National Forest but of a lesser magnitude. In 1981, there were 1,600 acres infested with only 150 acres by 1986. Again, none have been reported during the last 2 years.

Yellowstone National Park is an area of special concern because of recent fires and the destruction of endangered grizzly bear habitat. Similar trends were observed there with 34,000 acres being infested in 1983, however, no acreage has been reported the last few years. There are small populations of MPB, however, in some limber pine (*Pinus flexilis* James) stands near Mammoth.

In 1980, MPB infestation on the Flathead National Forest was 96,500 acres of whitebark pine. Infestations of whitebark pine dropped to 1,500 acres in 1986 and to only 100 acres last year. There has been no new acreage of infested whitebark pine observed in Glacier National Park for the past 3 years, however, earlier in 1980 there were 15,000 acres reported for whitebark pine and 292,000 acres for lodgepole pine.

AREA DESCRIPTIONS

Between 1983 and 1988, on-the-ground surveys were conducted to determine the extent of MPB in whitebark pine and surrounding tree types. These determinations were made on three areas: Gallatin National Forest, Flathead National Forest, and Yellowstone National Park.

Gallatin National Forest

In 1983, 211 data collection points were established at selected sites on the Gallatin National Forest. Fifty-six distinct stands were selected within three elevational zones (5,400-8,500 ft). These collection points were located on the Hebgen Lake, Bozeman, and Gardiner Ranger Districts (fig. 1). Eleven stands were found at lower elevations, in which Douglas-fir (*Pseudotsuga menziesii* [Mirbel] Franco) dominated; 25 stands were found at midelevations, in which lodgepole pine dominated, and 20 stands were found at high elevations, in which whitebark pine dominated. Even in the low-elevation stands, lodgepole pine was a major component. All stands were selected where whitebark pine occurred and where MPB was active or had been active in the recent past.

Yellowstone National Park

In 1987, 30 data collection points were established within the whitebark pine zone in Yellowstone National Park. The stands selected were mixed lodgepole and whitebark pine and occurred at about 8,300 ft elevation. All collection points were in the southwestern portion of Yellowstone National Park just west of Yellowstone Lake. Due to lack of ground access into high-elevation whitebark pine stands and the observation that most past beetle activity was confined to lodgepole pine stands, data were not collected from these high-elevation stands.

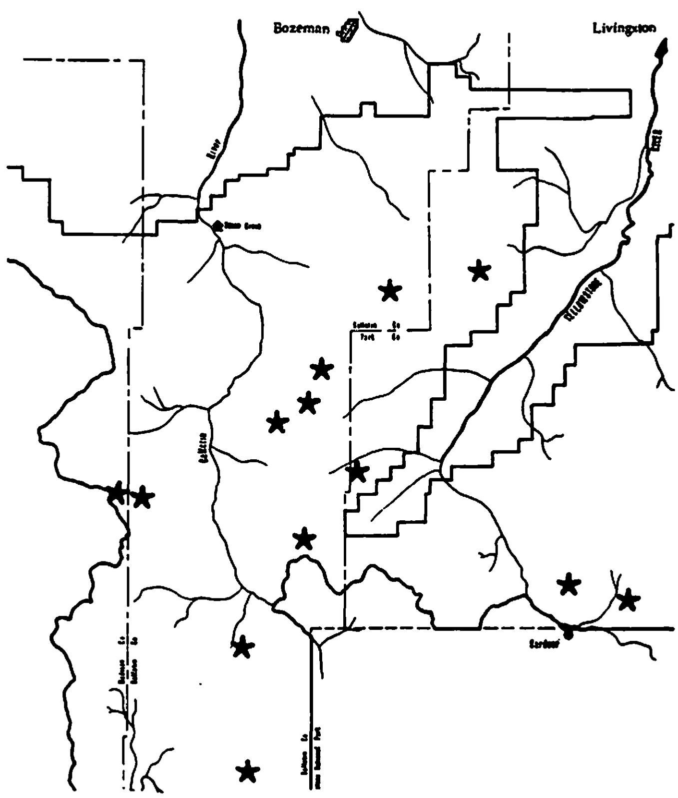

Figure 1—Map of Gallatin National Forest in southern Montana showing stand locations where sampling for MPB infestations was conducted during 1983.

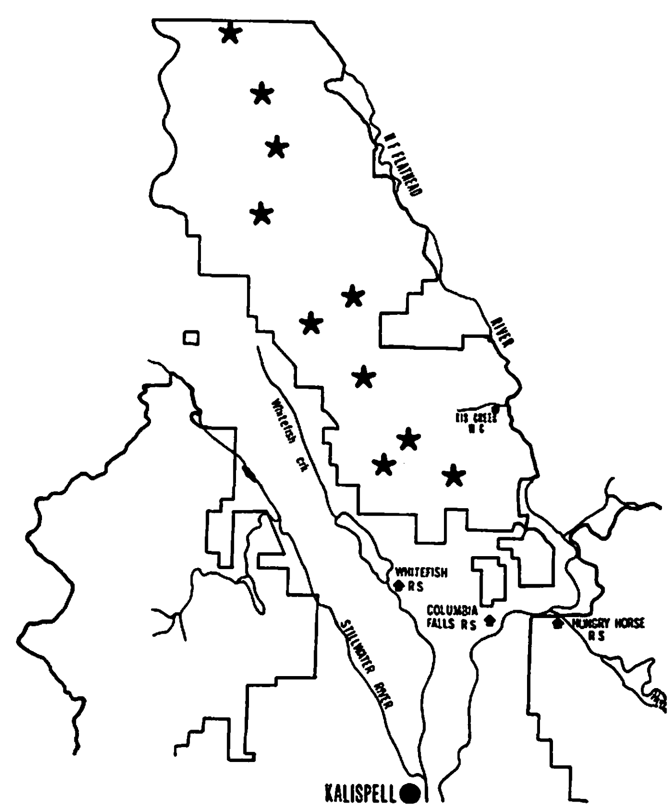

Figure 2—Map of Flathead National Forest in northern Montana showing stand locations where sampling for MPB infestations was conducted during 1988.

Flathead National Forest

To obtain data from a different geographical area, whitebark pine stands affected by MPB on the Flathead National Forest were sampled in 1988. Selected stands ranged in elevation from 5,500 to 6,600 ft, and were located exclusively on the Glacier View Ranger District in the Whitefish Mountain Range (fig. 2). Ten stands were visited—the northernmost was about 6 air miles south of the Canada-United States border and the southernmost was approximately 5 air miles north of Whitefish, MT. Number of plots per stand varied; a total of 80 plots was sampled. Stands were generally of mixed species; subalpine fir (*Abies lasiocarpa* [Hook.] Nutt.) dominated, and all fit the criteria for the subalpine fir habitat type.

METHODS

Number and spatial arrangement of the plots established in each area were determined by the size and shape of the stand visited. Whenever possible, a minimum of 10 plots was located in each stand. These plots were generally located at 5-chain intervals along a compass line coinciding with the long axis of the stand. Occasionally, plots were established on parallel lines 5 chains apart. The initial plot in each series was located randomly, but it was at least 2 chains within the stand's boundary.

On each plot, various stand and site data were collected to relate ecological factors to pest-caused damage. At each plot center, a variable radius plot (BAF 10) was established using a Spiegel Relaskop R. Each "in" tree, equal to or greater than 5 inches d.b.h. (diameter breast height) was recorded by species and d.b.h. In addition, each tree was assigned one of the following "damage" codes:

0 = undamaged, healthy tree
1 = unknown mortality
2 = current year MPB-caused mortality
3 = previous year MPB-caused mortality
4 = older MPB-caused mortality
5 = unsuccessful MPB attack
6 = current year MPB strip attack
7 = older MPB strip attack
8 = current secondary beetle-caused mortality
9 = older secondary beetle-caused mortality
10 = secondary beetle strip attack
49 = spike top usually white pine blister rust
50 = other damage

Heights and ages were measured on the first two dominant or codominant trees of each species encountered on the plot. The observer was at the center of the plot and turned in a clockwise direction starting from the direction of travel; trees were recorded as they were encountered.

The center of the variable-radius plot also served as the center for a 1/300-acre (6.8-ft diameter) fixed-radius plot on which were collected regeneration data. Only the four "best" trees (greater than 6 inches tall and less than 5 inches d.b.h.) were recorded.

In addition to the stand data, the following site data were recorded for each plot: elevation, slope, and aspect. At each plot, a "downed fuel inventory" was conducted to assess the amount and size of materials contributing to the fuel load on the site. Observations regarding presence and abundance of various wildlife species were noted. Evidence of big game (trails, droppings, shed antlers) was recorded by species. In addition, habitats (such as snags or caves), sightings, or other indications of non-game mammals and birds were tallied. Sampling was done to determine the amount (on a dry weight basis) of understory vegetation as a critical component of the system.

RESULTS AND DISCUSSION

The 1988 distribution map of MPB activity in the Northern Region (fig. 3) shows the greatest intensity of tree killing by MPB to occur in the northwestern part of Montana near the Canadian border. Mountain pine beetle activity is strongest in the lodgepole pine type with very little recorded in the ponderosa pine, western white pine, or whitebark pine type (fig. 4). One might say that there is nothing to worry about concerning the whitebark pine; however, Amman (1982), Parker (1973), and Wood (1963) stated there is strong evidence that any whitebark pine stands that occur above lodgepole pine stands could definitely be in danger of attack or devastation. Even if the whitebark pine stands are not in close association with lodgepole pine they are still at risk because infestations can occur during warmer than average years in the absence of lodgepole pine infestations (Baker and others 1971).

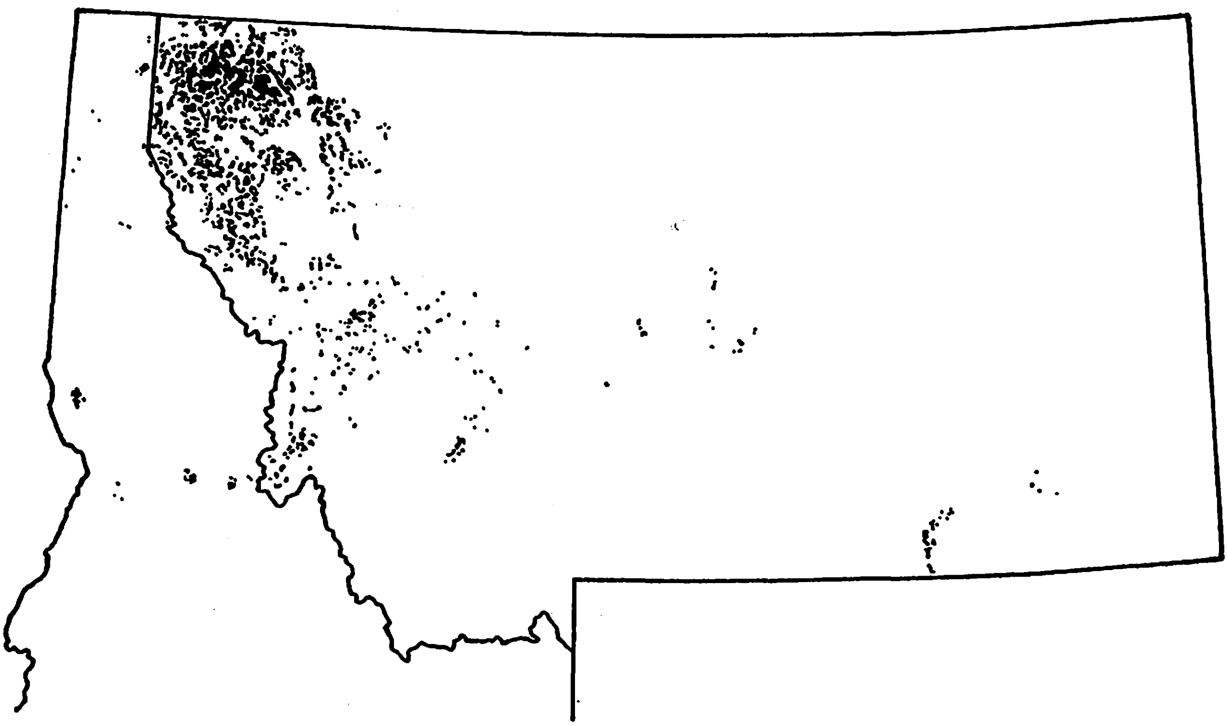

Figure 3—A map of the Northern Region showing the location of MPB infestations for 1988.

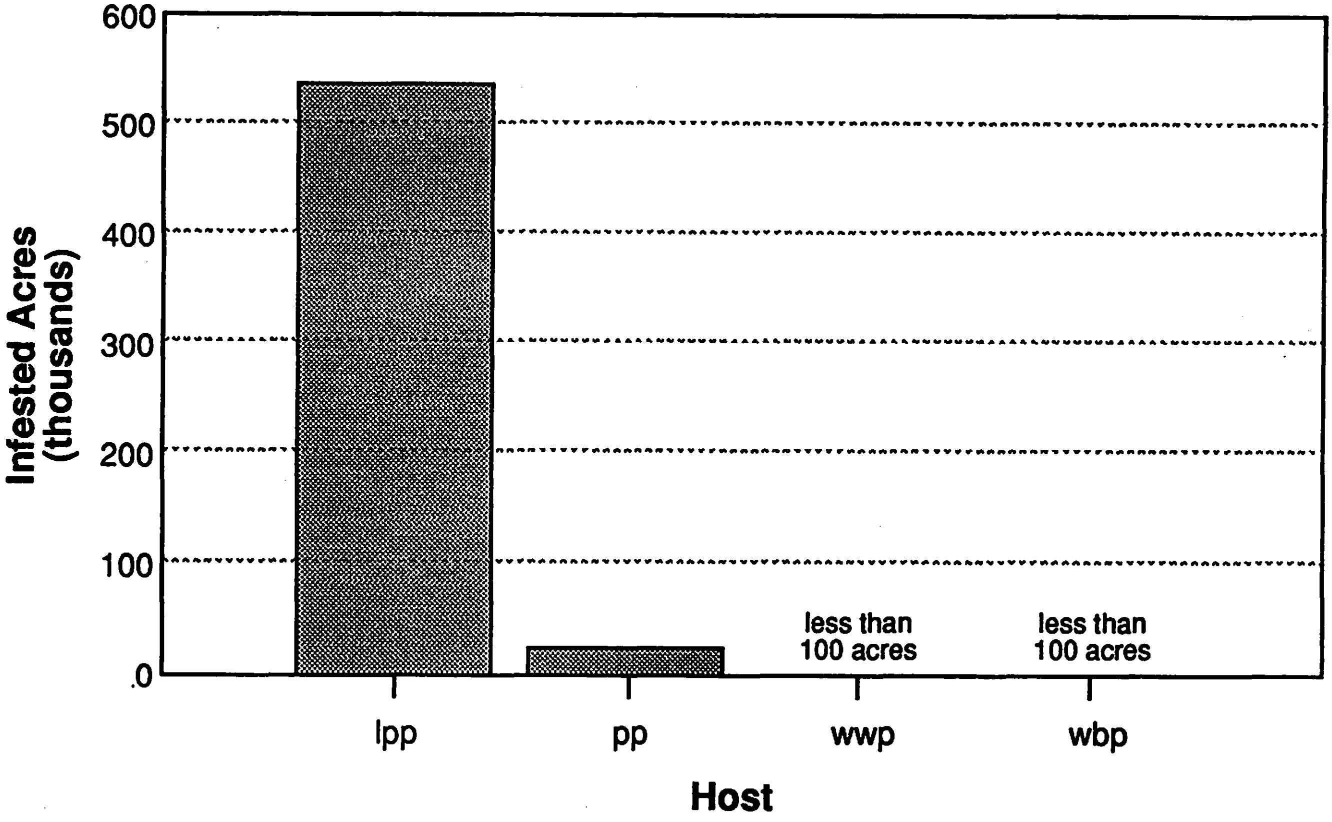

Figure 4—Acreage of MPB infestations in the Northern Region for 1988 for four host species: lodgepole (lpp), ponderosa (pp), western white (wwp), and whitebark pine (wbp).

Gallatin National Forest

Surveys during 1983 found MPB and unknown agents were the major killing agents of both lodgepole pine and whitebark pine across all 56 stands sampled (table 1). Mortality of lodgepole pine varied between 10 and 62 percent for the various size classes considered. Highest mortality was observed in the largest trees, 12 inches and larger d.b.h., while the least mortality was seen in the 5- to 9-inch d.b.h. category.

Similar trends were observed in the whitebark pine on the Gallatin National Forest (table 1). Where whitebark pine dominated, the most mortality occurred in the largest trees—23 percent of the 12 inch and larger. Even at the lowest elevations sampled, where Douglas-fir dominated, there was 60 percent mortality, caused by secondary beetles, of the 5- to 9-inch d.b.h. whitebark pine trees.

It should be noted that less than 10 percent of the MPB attacks at the time of the survey were current which shows most MPB activity occurred prior to the sample year and supports the fact that MPB activity peaked on the Gallatin National Forest in 1981. This information further substantiates what Arno and Hoff (1989), Ciesla and Furniss (1975), and Parker (1973) observed of outbreaks occurring in the lower lodgepole pine zone and moving up into the whitebark pine zone.

With almost a quarter of the dominant trees being killed in the whitebark pine zone, what effect will this mortality have on future forests? There will definitely be a reduction in the cone crop for the immediate future because the most mature trees were killed. It is safe to say that whitebark pine reproduction might suffer some and that one food source (pine nuts) for animals will be diminished. There may be a shift in the ecotonal zone between lodgepole pine and whitebark pine as a result of this mortality. Will the whitebark pine zone expand into the lower lodgepole pine area or vice versa? It is conceivable that the remaining whitebark pine may become more vigorous because of the "natural thinning" by MPB of both whitebark and lodgepole pine.

Yellowstone National Park

In our survey of Yellowstone National Park, MPB-caused mortality was not observed for the sample year or previous years. Accessibility to other high-elevation whitebark pine stands was not possible, therefore, the survey was limited. Furthermore, it was observed that most of the past beetle activity was confined to lower elevation lodgepole pine stands. Almost a million acres of lodgepole pine was infested in Yellowstone National Park in 1981. This was one of the main contributing factors to the tremendous fuel loads that existed in the National Park for the fire season of 1988.

Table 1—Summary of whitebark pine and lodgepole pine mortality due to mountain pine beetle for Gallatin National Forest for 1983

Elevational zones	No. of stands surveyed	Dominant tree species	D.b.h. classes 5-8.9 inch	9-11.9 inch	12 + inch
Killing agent/species[1]				*Percent mortality*	
Low elevation	11	Douglas-fir			
MPB/LPP			14.5	38.4	61.7
SEC/LPP			0.0	2.2	0.6
UNK/LPP			16.0	3.8	0.0
Total LPP			30.5	44.4	62.3
SEC/WBP			59.5	0.0	0.0
Mid elevation	25	Lodgepole pine			
MPB/LPP			16.3	38.9	53.2
SEC/LPP			6.1	2.1	1.6
UNK/LPP			2.2	0.6	1.5
Total LPP			24.6	41.6	56.3
High elevation	20	Whitebark pine			
MPB/LPP			0.0	5.5	39.3
SEC/LPP			5.6	4.3	5.0
UNK/LPP			6.9	0.0	0.0
Total LPP			12.5	9.8	44.3
MPB/WBP			0.8	5.3	19.1
SEC/WBP			1.4	5.0	2.2
UNK/WBP			0.7	1.7	2.0
Total WBP			2.9	12.0	23.3

[1]MPB = mountain pine beetle
SEC = secondary beetles
UNK = unknown agent
LPP = lodgepole pine
WBP = whitebark pine.

Flathead National Park

Stands were sampled in northern Montana to give a more complete picture of the effects of MPB on whitebark pine in the Northern Region. A summary of 80 plots that were sampled (table 2) shows a range of live whitebark pine 5-inch d.b.h. and larger varied between 1 tree/acre to 87 trees/acre. An average of 27 percent of the stand was composed of live whitebark pine and this varied between 1 and 63 percent for the 10 stands sampled. Percent mortality for the whitebark pine was between 14 and 97 percent with most of the kill occurring prior to 1987. Only a little mortality was recorded for 1987 and hardly any for 1988. This helps validate what was observed on the Gallatin National Forest and in Yellowstone National Park.

Effects of MPB on whitebark pine was directly connected to the peak infestation for the Region. Most of the mortality seen occurred between 1981 and 1987. If MPB infestations continue to decline, the remaining whitebark pine in the Northern Region will not likely succumb to MPB, at least in the near future.

Miscellaneous Observations

Total understory vegetation (current growth of shrubs, forbs, grasses, and grasslike species) was sampled to determine, in part, fine fuels that exist in the stands. On the Gallatin National Forest understory vegetation was sparse with values ranging from 166 to 1,217 lb/acre. Farther north on the Flathead National Forest, understory growth was considerably more with values of 1,090 to 1,748 lb/acre. Understory values of 166 lb/acre imply impoverished sites; and 1,748 lb/acre imply moderately stocked understory.

In the 10 areas sampled on the Flathead National Forest, most regeneration observed was subalpine fir. Next in occurrence was Engelmann spruce. On only four of the 10 areas sampled was whitebark pine regeneration noted, and then it was always in the minority. We did not observe whether this was due to lack of seeds or merely a successional pattern typical of subalpine fir habitat types.

Table 2—Summary of whitebark pine (WBP) mortality due to mountain pine beetle (MPB) for Flathead National Forest for 1988

Stand number	Green WBP 5 inch+	1988 MPB attacks	1987 MPB attacks	Older MPB attacks	Stand green WBP	WBP mortality	Secondary attacks	Blister rust damage
	Number/acre				*Percent*		*Number/acre*	
1	25.6	0.0	0.0	8.0	63	24	0.0	0.3
2	38.8	0.0	0.0	15.6	52	29	0.0	4.8
3	48.3	0.0	32.3	136.8	51	78	34.9	9.1
4	9.6	1.2	0.0	0.4	13	14	0.0	0.0
5	86.9	0.0	14.2	32.7	44	35	8.1	0.0
6	29.0	0.0	35.0	8.3	13	60	0.0	20.8
7	20.5	0.0	19.9	22.5	11	67	0.0	0.0
8	1.2	0.0	9.9	29.3	1	97	0.0	0.0
9	9.8	0.0	2.3	28.1	6	94	0.0	0.0
10	6.1	0.0	0.0	56.0	4	90	17.0	0.0
Average	27.3	0.1	13.4	36.2	27	65	6.5	4.7

CONCLUSIONS

In the Northern Region, whitebark pine was killed as a result of the epidemic MPB populations that peaked in this area during the early 1980's (an exception was Flathead National Forest, which peaked in 1986). Most information we have suggests that whitebark pine stands were infested by MPB populations originating in lower elevation lodgepole pine stands. This conclusion is substantiated by the literature. However, MPB can, and sometimes does, kill whitebark pine in the absence of adjacent infestations in lower elevation lodgepole pine stands.

For the most part, if we want to reduce mortality in whitebark pine stands it appears that we need to suppress MPB populations in lodgepole pine stands that occur at lower elevations. Thinning of lodgepole pine stands on the Kootenai, Lolo, and Flathead National Forests shows basal area reductions can significantly reduce losses to MPB (McGregor and others 1987). Such population reductions by stand manipulation should reduce the likelihood of MPB outbreaks in the higher elevation whitebark pine stands.

We suggest the following as ways of better understanding the interrelationship of pests and whitebark pine:

1. Monitor the effects of insect pests (not just MPB) in whitebark pine stands in other geographical locations in the Region.
2. Obtain more accurate information on the impacts of cone and seed pests on whitebark pine.
3. Gain a better understanding of the association between MPB and secondary bark beetles in whitebark pine stands.

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Speakers answered questions from the audience following their presentations. Following are the questions and answers on this topic:

Q. (from David Charlet)—Is work being done on improving rearing techniques of predatory wasps for introduction as a means of biological control?

A.—The only parasitic wasp of importance affecting MPB populations is the Braconid, *Coeloides brunneri* Viereck. It may exert a small amount of control on endemic beetle populations, however, at epidemic levels, it is probably of little consequence. Artificial rearing of this wasp has not been successful. To our knowledge, no work is currently being done in that area. Efforts are better spent trying to manipulate the host rather than the pest populations.

Q. (from Ron Lanner)—How much is known about the effects of white pine weevil on *Pinus albicaulis*?

A.—In our experience, the only host of the white pine weevil (*Pissodes strobi* Peck) in the Intermountain West is Engelmann spruce. Lodgepole pine is affected by a closely related species, *P. terminalis* Hopping. We have never observed, nor seen recorded in the literature, *P. terminalis* infesting whitebark pine.

Q. (from Jim Jacobs)—(a) Is whitebark pine a preferred host for beetles or do they choose it when all else is consumed, and is whitebark pine susceptible to blue stain fungus? (b) What percent of seeds are consumed by worms and do you think nutcrackers can recognize them?

A.—(a) Whitebark pine is not the *most* preferred host of MPB, but it will readily infest it, as it does virtually any pine species within its range. In order of preference (as judged by occurrence of damage caused), the beetles' choice of host is probably lodgepole pine, ponderosa pine, western white pine, whitebark/limber pine, and ornamental (exotic) pines. This scenario may be only applicable in the Intermountain West; in the Sierra Nevada, this list may vary somewhat. Yes, whitebark pine is susceptible to blue stain fungi. (b) We have not surveyed cone crops in whitebark pine stands nearly enough to estimate what proportion of the seeds may be affected by coneworms, cone beetles, midges, or seed chalcids. All, however, have been recorded as affecting whitebark pine seeds. This is an area where work is sorely needed. We would not hazard a guess as to whether or not nutcrackers can recognize infested seeds.

Q. (from Anonymous)—How much of the whitebark pine mortality from MPB occurs in endemic situations versus epidemic? (Also) can beetles overwinter in whitebark pine stands? What effect does tree vigor/phloem thickness have on susceptibility to beetle attack?

A.—We have little information on endemic MPB populations in whitebark pine stands. Beetles do kill some older, weaker individuals in endemic situations, but it is likely part of the "background" or naturally occurring mortality. Yes, MPB can overwinter in whitebark pine stands. Tree vigor—as exhibited by young healthy trees—is important in protecting them from endemic beetle populations. It is of less importance in full-scale epidemics. Also, phloem thickness is critical to the beetle as it is the food of the developing larvae. Trees with phloem too thin to support developing broods are seldom attacked.