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Net Precipitation Within Small Group Infestations of the Mountain Pine Beetle

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Net precipitation (amount of precipitation reaching the ground) was monitored within four small group infestations of the mountain pine beetle from October 1986 to October 1990. Net precipitation within each infested group was not significantly different than in its respective control. The lack of differences was attributed to needle retention on the infested trees during the first 2 years and to the presence of the bare, but dead, standing trees during the last 2 years. Sample size and aspect of the infested area may have influenced our ability to detect a change in net precipitation.

Keywords: Net precipitation, mountain pine beetle, lodgepole pine

The impact of the mountain pine beetle (MPB), *Dendroctonus ponderosae* Hopkins, on the timber resource has been well documented (Amman and Cole 1983, Klein et al. 1979, Roe and Amman 1970, Safranyik et al. 1975). Relatively undocumented but of potential importance is the impact infestations might have on evapotranspiration, water yield, and runoff from infested stands. Hydrologically, MPB infestations probably function similarly to partial cutting practices. Because harvesting 50% of the watershed basal area will cause a measurable increase in net precipitation[2] (Wilm and Dunford 1948), MPB infestations killing similar percentages of the stand basal area may cause a similar increase in net precipitation. Small infestations of 5 to 20 trees probably cause insignificant change in water yield unless a large number of such infestations exist on the watershed. On the other hand, when infestations of 50 to 100 trees coalesce into one large infested area such as the recent infestation in Glacier National Park (Robinson and Dooling 1978), they may influence water yield.

The primary example of a bark beetle infestation influencing water yield is the White River spruce beetle outbreak in Colorado. Following that outbreak, streamflow increased an estimated 2 inches (Love 1955). Later, increases were estimated at 1.6 to 1.9 inches (Mitchell and Love 1973). The increase in water yield was attributed to the change in vegetation cover (Bethlahmy 1975); in essence, the 99% mortality of the overstory spruce resulted in reduced interception, reduced evapotranspiration, and greater streamflow.

Changes of this magnitude also may result from MPB infestations. The only documented impact of MPB infestations on water yield was a 15% increase in annual water yield for a watershed in which 50% to 60% of the trees greater than 7 inches d.b.h. were killed (Potts 1984). The annual hydrograph was advanced 2 to 3 weeks, low flows showed a 10% increase, but peak runoff showed little increase (Potts 1984). The increase in yield was attributed to reduced evapotranspiration and interception loss following needle-fall from beetle-killed trees.

The impact of an MPB outbreak where stand mortality exceeds 50% is best documented in Potts (1984). His work does not, however, depict the impact of small group infestations nor the changes occurring during the transition from foliated live crowns to completely defoliated dead trees. While the increase in water yield from MPB outbreaks may duplicate that from clearcut timber harvests of similar size (Potts 1984), the significance of standing dead timber remains undetermined.

In the subalpine forest, timber harvest increases streamflow for a number of reasons. Once the tree is cut,

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[2]*Net precipitation equals the amount of precipitation reaching the ground.*

it no longer absorbs soil water and transpires it into the atmosphere. Depending on the circumstances, part or all of this water is available for increasing flow. Before harvest, the tree's canopy intercepts precipitation, and much of this intercepted precipitation is evaporated back to the atmosphere. Harvesting the tree allows a greater amount of total precipitation to reach the ground and, thus, increases streamflow. Finally, the pattern of tree removal may alter stand aerodynamics, causing snowpack redistribution, and an increased efficiency in generating streamflow.

Whether the effects of timber harvest and beetle-kill on these processes are similar is unknown. The effect on transpiration should be the same, because once dead, neither harvested nor beetled-killed trees will transpire. The effect on interception and redistribution could be different. Needles remain on the tree after beetle attack, and turn reddish brown about 1 year after infestation. More energy may be absorbed, thus increasing the evaporative component. Even after needle-fall (2 to 4 years following attack), the tree skeleton remains to cause some interception and to mitigate any aerodynamic change. Ultimately the tree will fall, and the effect then would be the same as if the tree had been cut, assuming stand regeneration or ground cover has not increased significantly.

In this study, we assumed the effects of beetle-kill and timber harvest on transpiration to be the same and, therefore, did not study it. Our study investigated the effect of beetle-kill on net precipitation by monitoring (1) snowpack accumulation and (2) summer interception during the 4 years following infestation. More specifically, this study evaluated the net precipitation (winter and summer) associated with four small MPB infestations and their respective controls.

Methods

Four small group infestations were selected north of Tabernash, Colorado. The infestations were located near Hurd Peak at elevations between 9,000 and 9,300 feet. Stand characteristics for the infested sites are given in table 1.

The four infested sites were multistoried, comprising at least two diameter and height classes. Because of the stand structure, the crowns did not form a closed canopy and openings were common on all sites. The MPB infestations killed nearly all of the trees greater than 9 inches d.b.h. on all sites except site C. Infested trees were intermixed with noninfested trees although the noninfested trees tended to be less than 8 inches d.b.h. The trees were infested in July-August 1986.

Table 1.—Stand characteristics of the four mountain pine beetle-infested sites.

Site	Basal area per acre	Mean d.b.h. Infested	Mean d.b.h. Noninfested	Infested trees	
	ft^2	inches		number	%
A	199	10.1	5.8	20	61
B	164	10.3	4.8	20	63
C	152	11.3	6.8	29	52
D	131	9.7	4.6	16	70

In October 1986, transect lines were established through each of the four infested sites and its respective nearby noninfested control, which was within 150 ft of the infested trees. One transect line was established in the infested areas at sites A and D; two at site B; and three at site C. Transect lines in the infested areas of sites B and C were parallel and 25 feet apart. More than one transect line was established in infested areas of sites B and C because the infested trees were more widespread. One transect line was established in each control.

Sampling points were established at 15-foot intervals along each transect line. The number of points for the infested areas were 10, 12, 26, and 10 for sites A, B, C, and D, respectively. Each control had 10 sampling points. Each sampling point was marked with a piece of lathe to insure that samples were drawn from the same point.

During the first week in April of each year, a snow survey was conducted at each site. Water equivalent (in inches) was determined from snow cores drawn from each sampling point in the infested and corresponding noninfested controls. In addition, precipitation gauges were set out at all sampling points on or about May 1 of each year and water equivalents (in inches of precipitation) were determined periodically from May 1 to October 1 of each year. Site D was discontinued in the fall of 1988 because firewood cutters cut the MPB-killed trees.

Total net precipitation for each sampling point for each year was determined by adding the water equivalents from the snow cores and the precipitation gauges. Mean net precipitation for each infested and noninfested area was determined by averaging the sampling points within each area. The means for each site were tested for significant differences with a t-test, $\alpha = 0.05$.

Results and Discussion

Net precipitation in each infested area was not significantly different from net precipitation in its respective noninfested area on any of the sites during any of the 4 years except for site B in 1987–1988 (table 2). The lack of differences between net precipitation in the infested and noninfested areas is not readily explainable and may result from a combination of factors, including needle retention, low precipitation, and sampling design.

During the first 2 years, the lack of differences was probably attributable to needle retention on the infested trees and, therefore, no difference in interception by the crowns. When the snow survey was made in April 1988, 70% to 80% of the needles were still present on the infested trees. Even though their needles were dead, the crowns of these trees probably intercepted essentially as much as the noninfested trees.

Table 2.—Annual net precipitation (inches) for four mountain pine beetle infested spots and their respective controls. Within a specific site and year, means followed by the same letter are not significantly different, $\alpha = 0.05$.

Site	Treatment	Year			
		1986–87	1987–88	1988–89	1989–90
		$X \pm SD$			
A	Infested	5.5±2.5a	9.3±2.7a	6.7 ±3.2a	6.3±2.9a
	Noninfested	6.9±1.9a	10.6±1.4a	7.6±1.8a	7.0±1.6a
B	Infested	7.0±2.0a	11.1±1.2a	8.3±2.1a	7.9±2.9a
	Noninfested	7.1±2.1a	11.0±2.5b	8.9±2.5a	8.5±2.5a
C	Infested	7.3±1.8a	11.0±1.5a	8.8±2.2a	8.1±2.1a
	Noninfested	7.4±1.3a	11.0±1.8a	9.7±1.6a	8.8±1.4a
D	Infested	7.8±3.5a	13.0±2.9a	Discontinued	
	Noninfested	6.6±3.4a	10.5±3.5a	Discontinued	

During the last 2 years (1988–1990), the loss of needles was more pronounced. Some trees had lost 90% of their needles by the first week in April 1989. By April 1990, the majority of the infested trees were essentially bare; a few trees retained 10% to 20% of their needles. Under these conditions, interception should have been negligible and differences in net precipitation more pronounced between infested and noninfested stands. Insignificant differences between infested and noninfested stands during 1989 and 1990 may have been compounded by below average precipitation. Precipitation at the Fraser Experimental Forest headquarters, which is about 7 miles SSW of the study area and at approximately the same elevation, was 3 inches below average in 1989 and 1990 (M. Martinez 1991, data on file at the Fraser Experimental Forest headquarters). Below average precipitation would tend to obscure any small differences between the infested and noninfested stands. Because differences did not exist, we conclude that small spot infestations in multistoried uneven-aged stands do not increase net precipitation. MPB-caused mortality in such stands tends to remove the larger diameter trees in the upper story (Cole and Amman 1980) and, thus, is intermixed with surviving smaller trees. Although the loss of leaf area of the MPB-killed trees should reduce interception, apparently this reduction is somewhat mitigated by the crown areas of the lower story(s) such that net precipitation is unchanged.

The similarities between partial cuts and beetle-infested areas may be valid only in even-aged stands where beetle-caused mortality exceeds a yet undefined percentage of the stand and after the beetle-killed trees have begun to lose branches or fall. Partial cutting of 50% of the basal area in a merchantable stand increased net precipitation by 10% (Wilm and Dunford 1948), but the same level of cutting produced only a 4% increase in snowpack in stands averaging 6 inches in diameter (Gary and Troendle 1982). Presumably, 50% mortality in even-aged stands of merchantable diameter would cause an increase in net precipitation comparable to the 4% to 10% obtained in the partial cuttings, but this may occur only after the trees lose their branches or fall.

The sample size for this study was based on previous observations at the Fraser Experimental Forest where winter snowpack averages ≥10 inches of water equivalent. Even under these conditions, determining changes in snowpack caused by timber harvest is difficult (Troendle and King 1985). Recent attempts to reduce interception losses through tree harvest have also shown that aspect interacts with timber harvest (Troendle and King 1987). North slopes appear to retain more snow than south slopes because less snow is lost to evaporation. Based on these recent developments and the below average precipitation, our sample size may not have been adequate to detect small changes, if indeed they did occur.

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