Silvicultural Control of the Mountain Pine Beetle in Ponderosa and Lodgepole Pines

Founders Award Address by Gene D. Amman

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As many of you know, where we are meeting today is an area of historical significance for forest entomologists. A.D. Hopkins described *Dendroctonus ponderosae* in 1902 from specimens collected in the Black Hills. He called it the pine destroying beetle of the Black Hills. Three years later, Hopkins (1905) gave more details about *D. ponderosae*, and shortened the name to the Black Hills beetle. As the taxonomy and host relationships were sorted out over the next 60 years, Steve Wood (1963) concluded that the mountain pine beetle, *D. monticolae*, and *D. ponderosae* were one and the same species. This species varies greatly in size according to host species, nutrition, and crowding during the larval stage. The common name, Black Hills beetle, seemed too restrictive for such a widely distributed species, so mountain pine beetle was retained for the common name.

The topic I have chosen for my lecture is Silvicultural control of the mountain pine beetle in ponderosa and lodgepole pines. We have come a long way from those early observations of A.D. Hopkins to our present state of knowledge encompassing over 1,200 publications about the mountain pine beetle. I want to emphasize that all of these have been important to our progress. In 1905, Hopkins recommended cutting the infested trees and debarking them. Also, he suggested burning or scorching the infested trees.

Silvicultural treatments specifically directed at the mountain pine beetle in ponderosa pine began in 1938 with a crop tree thinning experiment by Eaton (1941). Unfortunately, his experiment was destroyed by fire a few years later, according to Sartwell (1971). In 1960-61, Hall and Davis (1968, unpublished) reported two small tests of one thinning level on the Modoc National Forest. The unthinned stand was "decimated" by mountain pine beetle, whereas mortality in the thinned portion of the stand was minimal during the first few years of the test.

Sartwell and Dolph (1976) reported thinning stands of ponderosa pine in eastern Oregon. They used four thinning levels and check stands. Five years later, mortality in the thinned stands had been reduced over 90%. During the 1976 to 1982 period, the thinnings were subjected to one of the largest beetle outbreaks of record. Thinnings that were spaced 18 x 18 and those spaced 21 x 21 feet experienced little mortality (Dolph 1982). Closer spacings suffered considerable mortality.

To reduce ponderosa pine losses to mountain pine beetle, Sartwell and Stevens (1975) recommended thinning to 150 sq. ft. in the Black Hills. Preliminary results of thinnings in the Black Hills reduced tree losses to the mountain pine beetle (McCambridge and Stevens 1982). Stevens, Myers, McCambridge, Downing and Laut (1974) recommended thinning on the Front Range in Colorado.

In a three-year study in the Black Hills, Schmid and Mata (1992) found no mortality in partial cut stands that had growing stock levels equal or less than 100. In a seven-year study in 70 to 90 year old second growth ponderosa pine on the Lassen National Forest, Fiddler, Fiddler, Hart and McDonald (1989), reported no losses in thinnings that reduced the basal area to 80 sq. ft. Only light losses occurred at basal areas of 100 and 140 when compared to check stands that had basal areas of 190 sq. ft.

Silvicultural control of the mountain pine beetle in lodgepole pine began in the late 1960s with recommendations for patch cutting to create mosaics of age and size classes that would reduce acreage highly susceptible to mountain pine beetle at any one time; conversion of stands to nonhost type (Roe and Amman 1970; Safranyik, Shrimpton, Whitney 1974). D.M. Cole (1978) outlined a number of silvicultural practices to reduce losses to mountain pine beetle.

During epidemic periods, the mountain pine beetle is strongly oriented to large diameter trees, but more so in lodgepole than in ponderosa pine. The correlation of tree mortality indicated that mortality could be reduced by removing large diameter lodgepole from stands (Cole and Cahill 1976).

When the mountain pine beetle does infest a tree in a thinned stand, usually only the single tree and occasionally a nearby tree, is infested. Geizler and Gara (1978) emphasized the importance of tree spacing in switching of attacks from a tree under attack to a nearby tree. If the distance is too great, infestation within the stand will not continue.

In 1978, Cahill reported 2% mortality due to mountain pine beetle in partial cut stands of lodgepole pine. Thirty-nine percent of the trees were killed in check stands. In 1987, McGregor, Amman, Schmitz and Oakes reported the results of a five-year study in Montana involving diameter limit cuts and spaced thinnings in lodgepole. Treatments were the removal of trees 10 inches and larger, and 12 inches and larger DBH, and reducing the basal areas of other plots to 80, 100, and 120 sq. ft. Compared to the 70% and 94% loss of trees in the check stands to the mountain pine beetle, losses were about 10% to 15% except in the 120BA and 12 inch diameter limit cuts, which suffered heavier losses. In 1985, Cole, Cahill and Lessard (1985) reported reducing losses to mountain pine beetle in lodgepole pine on the Shoshone National Forest during the first two years after partial cutting stands. Amman, Lessard, Rasmussen and O'Neal (1988) carried on the study until beetle populations declined. Check stands sustained 26.5% mortality compared to 3% or less in the thinning: consisting of 7-inch, 10-inch, and 12-inch diameter limit cuttings, and spaced thinnings leaving 100 trees/acre.

In Montana, Hamel (1978) attempted to reduce infestation of lodgepole pine by removal of trees that had thick phloem, but the test failed. The basic relationship between attack by the beetle and diameter of the tree could not be altered. The propensity of beetles to be attracted visually to large vertical objects, based on the work of Roy Shepherd (1966), precluded the success of this experiment (Hamel 1978).

These thinning operations have been assumed to increase tree vigor, and undoubtedly they do increase tree growth, but an increase in tree vigor does not occur immediately. Some stands take two to three years to respond (Amman, McGregor, Schmitz and Oakes 1988). Therefore, the idea of change in microclimate, which occurs immediately after a stand is thinned, was introduced to explain the decrease in tree mortality in thinned stands (Bartos and Amman 1989).

Mountain pine beetle flight is affected by temperature, wind speed, and light intensity. In lodgepole pine stands ground temperatures and south side tree temperatures were warmer in thinned than unthinned stands as observed by Bartos and Amman (1989) and Schmid, Mata and Schmidt (1993). North side temperatures were not significantly different from air temperatures.

Light intensity is another factor governing flight of the mountain pine beetle. Roy Shepherd (1966) demonstrated under laboratory conditions that mountain pine beetles increased attempts to fly at high light intensities and increased temperature, conditions that were found in thinned stands (Bartos and Amman). Gray, Billings and Johnsey (1972) observed 59% of beetles flew with the wind, but more flew against the wind when speeds were less than 3.1 miles per hour. No flight occurred at wind speeds of 5 to 6 miles per hour. Observations by Bartos and Amman (1988) showed that wind speeds averaged consistently faster in a thinned than in an unthinned lodgepole pine stand during the hours of 4 to 6 p.m., the hours of most beetle flight observed by Rasmussen (1972), but the overall difference of 1.2 miles/hour was not significant.

Finally, solar insolation that could be responsible for warming the air and creating conduction currents, could carry odors out of, and above, the crown area, making it difficult for a beetle to locate a point source of attractant, either kairomone or pheromone. All of these factors are integrated into the beetles' response when responding to traps baited with aggregative pheromones. Only 5% of the 504 beetles were caught in a thinned stand, having an average basal area of 67 sq. ft., compared to 478 beetles caught in traps in the unthinned stand having an average basal area of 137 sq. ft.

Schmitz, McGregor, Amman and Oakes (1989) caught fewer beetles in passive barrier traps in heavily thinned than in lightly thinned and check stands in Montana, even though large numbers of beetles were flying through the thinned stands. John Schmid and his colleagues Mata, Olsen, Allen, Schmidt, and Vigil conducted a series of studies to answer the question of why beetles make limited attacks only in ponderosa and lodgepole thinnings (Schmid, Mata, and Schmidt 1991; Schmid, Mata and Allen 1992; Schmid, Mata, and Schmidt 1992; Schmid, Mata, Olsen and Vigil 1993; Schmid, Mata and Olsen 1995). They have measured air and bark temperatures, horizontal and vertical wind speeds, and solar radiation. They conclude that only solar radiation and, perhaps, vertical air movement or turbulence would appear to play an important role in mountain pine beetle selection of particular stands. Therefore, effects that thinnings have on stand microclimate and behavioral response of mountain pine beetle, is far from being a closed subject.

In spite of the large knowledge base for the mountain pine beetle, there is still much to do. Concerning research needs, my list is far from exhaustive, and I acknowledge borrowing freely from the ideas of my colleagues on the Mountain Pine Beetle Project, Jesse Logan, Barbara Bentz, Dale Bartos, Lynn Rasmussen and Ken Hobson. The ecologically most interesting and important processes are little understood. For example, the first is the central question in mountain pine beetle research: What triggers or induces an outbreak: Second, what is the Relationship among fire, root disease, and mountain pine beetle? The third involves the series of events leading to ecosystem recovery following disruption by large beetle infestations. Fourth is the effect that fire protection has had on the extent and intensity of mountain pine beetle infestations. Fire undoubtedly has had greater effect on an ecosystem, but beetle infestations cover more extensive areas than the average fire. Fifth is the question: What are the ecological effects of large beetle infestations in ponderosa and lodgepole pine forests? Sixth: How long is the recovery process following an infestation? Seventh: How is global warming going to affect beetle infestations, and what management strategies will be needed to mitigate those effects? Eighth: What sizes and shape of ecological units and the species mix will be needed to maintain ecosystem integrity? Ninth: What type and intensity of management activities can the ecosystem sustain and remain intact?

As you can see, I have a lot of questions, but few answers. And my questions center on large ecological processes. Many of us here today have laid the groundwork for the next generation to find answers to such concerns. In the current scientific interest in ecosystems, the search may take slightly different and unexpected directions than what some of us experienced in the past. However, one thing is evident: We will need to accept disturbance events as basic to maintaining ecosystem integrity.

I acknowledge my fellow entomologists in these efforts to apply and fathom the reasons behind silvicultural control of mountain pine beetle: Dale Bartos; Dennis Cole; Walt Cole; Donn Cahill; Ken Gibson; Gene Lessard; Ken Lister; Mark McGregor; Les McMullen; Bob Oakes; Judy Pasek; Lynn Rasmussen; Les Safranyik; John Schmid; Malcolm Shrimpton; Dick Schmitz; and Stu Whitney. My wife, Jeanette, has been a constant source of support and encouragement. Also, I acknowledge Fred Knight who opened the door to educational opportunity. I thank my nominators and the Western Forest Insect Work Conference Awards Committee for selecting me for the Founder's Award. I am deeply honored.

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