Forest Insect
& Disease
Leaflet 2

U.S. Department
of Agriculture
Forest Service

Mountain Pine Beetle

Gene D. Amman,[1] Mark D. McGregor,[2] and Robert E. Dolph, Jr.[3]

The mountain pine beetle, *Dendroctonus ponderosae* Hopkins, is a member of a group of beetles known as bark beetles. Except when adults emerge and attack new trees, the mountain pine beetle completes its life cycle under the bark.

The beetle attacks and kills lodgepole, ponderosa, sugar, and western white pines. Outbreaks frequently develop in lodgepole pine stands that

[1]Principal entomologist, U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station, Ogden, UT.

[2]Entomologist, U.S. Department of Agriculture, Forest Service, Cooperative Forestry and Pest Management, Northern Region, Missoula, MT.

[3]Entomologist, U.S. Department of Agriculture, Forest Service, Forest Pest Management, State and Private Forestry, Pacific Northwest Region, Portland, OR.

contain well-distributed, large-diameter trees or in dense stands of pole-sized ponderosa pine. When outbreaks are extensive, millions of trees may be killed each year. Periodic losses of high-value, mature sugar and western white pines are less widespread but also serious.

During epidemics, widespread tree mortality alters the forest ecosystem. Often, beetles have almost totally depleted commercial pine forests and, in some cases, have converted valuable forests to less desirable timber species, such as subalpine fir. Sometimes, forested areas are converted to grass and shrubs. The profusion of beetle-killed trees can change wildlife species composition and distribution by altering hiding and thermal cover and by impeding movement. Tree mortality may increase the water yield for several years following an infestation. Moreover, the dead trees left after epidemics are a source of fuel that will, in time, burn unless removed.

Figure 1

Mountain Pine Beetle

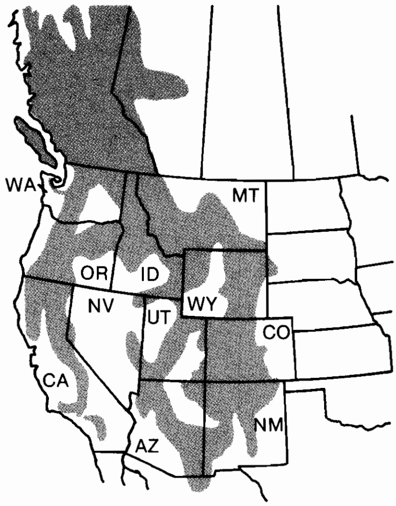

Figure 1—*Probable distribution of the mountain pine beetle in North America.*

Range and Hosts

The beetle is native to North America. It is found in an area from the Pacific Coast east to the Black Hills of South Dakota and from northern British Columbia and western Alberta south into northwestern Mexico (fig. 1). Its habitat ranges from near sea level in British Columbia to 11,000 feet (3,353 m) in southern California.

The four major hosts of the mountain pine beetle are lodgepole, ponderosa, sugar, and white pines.

Limber, Coulter, foxtail, whitebark, pinyon, and bristlecone pines are also infested and killed. Scotch pine, an exotic in North America, is highly susceptible to attack. Douglas-fir, true firs, spruce, larch, and incense cedar are occasionally attacked, but because they are not true hosts, broods rarely develop. Attacks on nonhost trees usually occur when nearby pines are heavily infested.

Evidence of Infestation

The mountain pine beetle begins attacking most pine species on the lower 15 feet (4.4 m) of the trunk. Trees are generally killed by beetles of a single generation.

However, large sugar pines are first attacked in the crown. Two or more generations of beetles—each generation attacking a lower portion—may occur before the tree is killed.

Examination of infested trees usually reveals the presence of pitch tubes. Pitch tubes are made when female beetles bore into the tree. There are two types of tubes. Pitch tubes on successfully infested trees are cream to dark-red masses of resin mixed with boring dust and are one-fourth to one-half inch (6 to 13 mm) in diameter. Pitch tubes on unsuccessfully infested trees are larger, three-fourths of an inch to 1 inch (19 to 25 mm) in diameter, and widely scattered over the trunk. When beetles are not present in sufficient numbers, trees can produce enough resin to "pitch out" beetles as they bore into the inner bark (fig. 2).

Besides having pitch tubes, successfully infested trees will have dry boring dust, similar to fine sawdust, in bark crevices and around the base of the tree (fig. 3). Sometimes, however, infested trees can have boring dust, but not pitch tubes. These trees, called blind attacks, are common during drought years when trees produce little pitch.

Figure 2—*Unsuccessfully attacked tree has "pitched out" beetle.*

Figure 3—*Pitch tubes on the trunk and boring dust around the base indicate that this lodgepole pine has been attacked and killed by the beetle.*

When the beetles attack, they carry blue-staining fungi into the tree. After one to several months, the sapwood begins to discolor (fig. 4).

Woodpeckers, feeding on larvae under the bark, make individual holes in thick bark, or they may partially or completely remove thinner bark. These signs, plus the resulting pile of bark flakes around the base of the tree, are good evidence of bark beetle infestation.

The first sign of beetle-caused mortality is generally discolored foliage. Needles on successfully infested trees begin fading and changing color several months to 1 year after the trees have been attacked. The needles change from green to yellowish green, then sorrel, red, and finally rusty brown (fig. 5). Fading begins in the lower crown and progresses upward.

In large sugar pines, fading in the upper crown is the first evidence of infestation.

Figure 4—*Sapwood has been discolored by blue-staining fungi; heartwood is not stained.*

Figure 5—*Dying trees. Discolored foliage is a sign that these lodgepole pines have been attacked and killed by the mountain pine beetle.*

Figure 6—*Bark beetle galleries form an identifying pattern. Mountain pine beetle egg galleries are vertical. The larvae construct their feeding galleries at right angles to the egg galleries.*

Life History

The beetle develops through four stages: egg, larva, pupa, and adult. Except for a few days during the summer when adults emerge and fly to new trees, all stages are spent under the bark of infested trees.

The beetle usually takes 1 year to complete its life cycle. However, at high elevations where summer temperatures are cool, 2 years may be required to complete the life cycle. And in California, two generations may be produced in 1 year in low-elevation sugar pines.

Under the bark, female beetles construct straight, vertical egg galleries. Packed with boring dust, these galleries are mostly in the phloem, or inner bark, although they slightly score the sapwood. They range from 4 to 48 inches (10 to 122 cm) long, averaging about 10 inches (25 cm) (fig. 6).

Females lay tiny, pearl-white eggs in niches along the sides of the galleries, usually during the summer and early fall. The eggs hatch in 10 to 14 days, although they may take longer during cool weather. (See cover photo.)

Sometimes, eggs are also laid in late spring by females that survived the winter. Surviving females may either reemerge and reattack trees or merely extend their egg galleries.

The legless larvae are white with brown heads. This stage lasts for about 10 months—from August to the following June. The larval broods feed on the phloem, constructing galleries that extend at right angles to the egg galleries. When mature, larvae excavate oval cells in which they turn into pupae. By July, the pupae usually have been transformed into adults.

Adults feed within the bark before they emerge; when several feeding chambers coalesce, adults occur in groups. One or more beetles will then make an exit hole (fig. 7) from which several adults will emerge. Within 1 or 2 days after emerging, the beetles will attack other trees.

Figure 7—*Exit holes, about 3/32 inch (2.4 mm) in diameter, made by mountain pine beetles.*

Unmated female beetles making the first attacks release chemicals called aggregating pheromones. These pheromones attract males and other females until a mass attack overcomes the tree. Adjacent trees are then infested.

Attacking beetles carry with them the spores of blue-staining fungi on their bodies and in a special structure on their heads. As the fungi develop and spread throughout the sapwood, they interrupt the flow of water to the crown. The fungi also reduce the tree's flow of pitch, thus aiding the beetles in overcoming the tree. The combined action of both beetles and fungi causes the tree to die and the needles to discolor.

Factors Affecting Outbreaks

A number of factors can affect the size of mountain pine beetle populations.

Food Supply. The food supply regulates populations of the beetle. Beetles usually select larger lodgepole pines that have thick phloem. They need adequate food, found in large-diameter trees, for their population to build up. After the larger lodgepole pines are killed, beetles infest smaller and smaller trees, where phloem is thin and excessive drying occurs. Beetle populations then decline to endemic levels.

The relationship between beetle populations and phloem thickness has not been established for other tree species.

Tree Resistance. A copious pitch flow from some pines can prevent successful attack. In effect, the beetles drown in the pitch as they bore into the inner bark or must abandon the tree. The number of attacking beetles, the characteristics of the tree, and the weather affect a tree's ability to produce enough resin to resist attack. But if a large number of beetles attack a tree, the beetles can successfully overcome the tree's ability to pitch them out.

Predators and Parasites. Nematodes, internal parasitic worms, can hinder or prevent egg production. Other nematodes feed on eggs after they are laid by the females.

Woodpeckers feed heavily on larvae in some trees. Woodpeckers, in their search for larvae, make holes in the bark, causing the bark to dry and thus killing additional beetles. Woodpeckers probably play a role in reducing beetle numbers during endemic periods but do not control the beetles during epidemics. Several other bird species, including nuthatches, feed on adults exposed during flight or as they attack.

A dolichopodid fly and two species of checkered beetles (fig. 8) are common predators: they may reduce beetle numbers in individual trees but seldom affect mountain pine beetle infestations. Parasitic wasps sometimes cause substantial mortality in trees where their short ovipositors can reach the larvae through the thin bark.

Figure 8—*A checkered beetle (* Enoclerus sphegeus *Fabricius) eating a mountain pine beetle adult.*

Figure 9—*Larvae of the round-headed woodborer (see larva near top of photo) have devoured both the phloem and the mountain pine beetle brood.*

Competition. Larvae compete for food and space not only with each other but with larvae of other beetles. For example, the larvae of the round-headed woodborers, feeding within the inner bark, occasionally destroy almost all of the mountain pine beetle brood found there (fig. 9).

Cold Temperature. Unseasonably low temperatures may retard outbreaks. Early autumn or mid-spring temperatures of about 0 °F (−18 °C) and winter temperatures below −34 °F (−37 °C) may affect outbreaks.

Unfortunately, such cold temperatures may affect only low-lying areas; beetles survive on warmer slopes. Beetles in thick-barked trees and in portions of tree trunks that are below the snow line are also protected from the cold and more likely to survive.

Stand Hazard Rating

Resource managers can take appropriate action to prevent outbreaks or reduce damage if they can identify those stands having characteristics that lead to bark beetle infestations. This process of risk assessment is called hazard rating, and several methods of hazard rating pine stands are available. These methods are based on characteristics frequently associated with epidemics. Computer models are available to predict losses to mountain pine beetle based on stand structure and habitat type. It is still not possible, however, to predict *when* stands will become infested.

Figure 10—*High-risk ponderosa pine stands attacked by the beetle. Trees with yellow foliage have been recently attacked; gray trees were killed the year before the trees with yellow foliage were attacked.*

High-risk lodgepole pine stands have an average age of more than 80, an average diameter at breast height of more than 8 inches (20 cm), and a suitable climate for beetle development based on elevation and latitude.

In second-growth ponderosa pine, high-risk stands have a high stand basal area, a single story, and an average diameter at breast height more than 10 inches (25 cm) (fig. 10).

Control

Control options available for managing the mountain pine beetle depend somewhat on the size of the outbreak, the age of the stand, the size of the trees, and the conditions of the site.

Silviculture. Silvicultural control measures are the most efficient.

Thinning stands of lodgepole and ponderosa pines will prevent or minimize beetle-caused mortality. Patch cutting in lodgepole pine stands creates a mosaic of age and size classes, which reduces the acreage of lodgepole pine that will be highly susceptible to beetles at one time.

Where clear or patch cutting is not feasible, selective harvesting will help reduce mortality. Trees can be harvested selectively in riparian zones and in areas along roads, in campgrounds, and around scenic vistas.

Salvage can retrieve wood that otherwise would be lost, and if beetles are removed with the tree and disposed of, some reduction in the beetle population can be expected. However, once a large outbreak has developed, salvage logging of infested material to reduce future tree mortality generally will not be effective.

Insecticides. Insecticides are available for direct control of beetles in infested trees. The use of insecticides in such situations requires the combined efforts of all landowners within the designated management area. However, if beetle outbreaks are large, direct chemical control may not be cost effective: treatment costs may exceed the value of the wood apparently saved. At best, insecticides provide a temporary control measure that slows infestations. They will not stop an outbreak as long as the susceptible stands remain unaltered.

Preventive spraying before trees become infested will protect individual high-value trees. Such preventive treatment does not require a united effort by landowners as does the treatment of infested trees. However, periodic treatments will be necessary for as long as the outbreak lasts.

Insecticides are reviewed continuously by the U.S. Environmental Protection Agency; persons contemplating the use of insecticides should ensure that they are still registered.

Attractants. Synthetic beetle attractants are now available to manipulate and monitor small outbreaks. Baiting and trapping with attractants, managers can contain small spot infestations, thus preventing their spread into susceptible stands and maintaining beetle populations at low levels until roads can be built, allowing for stand management. Using these new tools, managers can also protect high-value campgrounds and other recreation sites.

Information. Private landowners can get information about mountain pine beetle management from a Cooperative Extension agent at their land-grant college, a State agricultural experiment station, a county Extension office, the local State forestry office, or the Forest Pest Management staff, U.S. Department of Agriculture, Forest Service. Federal resource managers should contact the Forest Pest Management staff in their area.

References

Amman, Gene D.; Cole, Walter E. Mountain pine beetle dynamics in lodgepole pine forests. Part II: population dynamics. Gen. Tech. Rep. INT–145. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station; 1983. 59 p.

Amman, Gene D.; McGregor, Mark D.; Cahill, Donn B.; Klein, William H. Guidelines for reducing losses of lodgepole pine to the mountain pine beetle in unmanaged stands in the Rocky Mountains. Gen. Tech. Rep. INT–36. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station; 1977. 19 p.

Berryman, Alan A.; Amman, Gene D.; Stark, Ronald W., eds. Theory and practice of mountain pine beetle management in lodgepole pine forests: Proceeding of a symposium; 1978 April 25–27; Pullman, WA. Moscow, ID: University of Idaho, Forest, Wildlife and Range Experiment Station; 1978. 224 p.

Borden, J. H.; Chong, L. J.; Pratt, K. E. G.; Gray, D. R. The application of behavior-modifying chemicals to contain infestations of the mountain pine beetle, *Dendroctonus ponderosae*. Forestry Chronicle. 1983 October: 235–239.

Cole, Walter E. Some risks and causes of mortality in mountain pine beetle populations: a long-term analysis. Researches in Population Ecology. 23(1): 116–144; 1981.

Cole, Walter E; Amman, Gene D. Mountain pine beetle dynamics in lodgepole pine forests. Part I: course of an infestation. Gen. Tech. Rep. INT–89. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station; 1980. 56 p.

Cole, Walter E.; McGregor, Mark D. Estimating the rate and amount of tree loss from mountain pine beetle infestations. Res. Pap. INT–318. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station; 1983. 22 p.

McCambridge, William F.; Hawksworth, Frank G.; Edminster, Carleton B.; Laut, John G. Ponderosa pine mortality resulting from a mountain pine beetle outbreak. Res. Pap. RM–235. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station; 1982. 7 p.

McGregor, M. D.; Amman, G. D.; Cole, W. E. Hazard-rating lodgepole pine for susceptibility to mountain pine beetle infestation. In: Hedden, R. L.; Barras, S. J.; Coster, J. E. Hazard-rating systems in forest insect pest management: Proceedings of a symposium; 1980 July 31–August 1; Athens, GA. Gen. Tech. Rep. WO–27. Washington, DC: U.S. Department of Agriculture, Forest Service; 1981: 99–104.

Safranyik, L.; Shrimpton, D. M.; Whitney, H. S. Management of lodgepole pine to reduce losses from the mountain pine beetle. Tech. Rep. 1. Victoria, BC: Canadian Forestry Service, Pacific Forest Research Centre, Department of the Environment; 1974. 24 p.

Sartwell, C.; Dolph, R. E., Jr. Silvicultural and direct control of mountain pine beetle in second-growth ponderosa pine. Res. Note PNW–268. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station; 1976. 8 p.

Stevens, R. E.; McCambridge, W. F.; Edminster, C. B. Risk rating guide for mountain pine beetle in Black Hills ponderosa pine. Res. Note RM–385. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station; 1980. 2 p.

Struble, George R. Attack pattern of mountain pine beetle in sugar pine stands. Res. Note PSW–60. Berkeley, CA: U.S. Department of Agriculture. Forest Service, Pacific Southwest Forest and Range Experiment Station; 1965. 7 p.

Pesticides used improperly can be injurious to human beings, animals, and plants. Follow the directions and heed all precautions on labels. Store pesticides in original containers under lock and key—out of the reach of children and animals—and away from food and feed.

Apply pesticides so that they do not endanger humans, livestock, crops, beneficial insects, fish, and wildlife. Do not apply pesticides where there is danger of drift when honey bees or other pollinating insects are visiting plants, or in ways that may contaminate water or leave illegal residues.

Avoid prolonged inhalation of pesticide sprays or dusts; wear protective clothing and equipment, if specified on the label.

If your hands become contaminated with a pesticide, do not eat or drink until you have washed. In case a pesticide is swallowed or gets in the eyes, follow the first aid treatment given on the label, and get prompt medical attention. If a pesticide is spilled on your skin or clothing, remove clothing immediately and wash skin thoroughly.

NOTE: Some States have restrictions on the use of certain pesticides. Check your State and local regulations. Also, because registrations of pesticides are under constant review by the U.S Environmental Protection Agency, consult your local forest pathologist, county agriculture agent, or State extension specialist to be sure the intended use is still registered.

Revised June 1985