study of tree root rots, dwarf mistletoe infections, and attacks by other insects that may set the stage for beetle attacks.

Additional research also is needed to evaluate alternative methods of beetle control. Possibilities include chemical attractants, repellants, and protective substances, and effective methods to apply them to tree stands without impairing natural forest values.

Expanding knowledge of the mountain pine beetle, plus expanding markets for lodgepole pine harvested in prevention programs, will help contain the tiny black beetles and assure a continuing supply of green trees in the Rocky Mountains.

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and
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Lodgepole pine killed by the mountain pine beetle (Caribou National Forest, Idaho).

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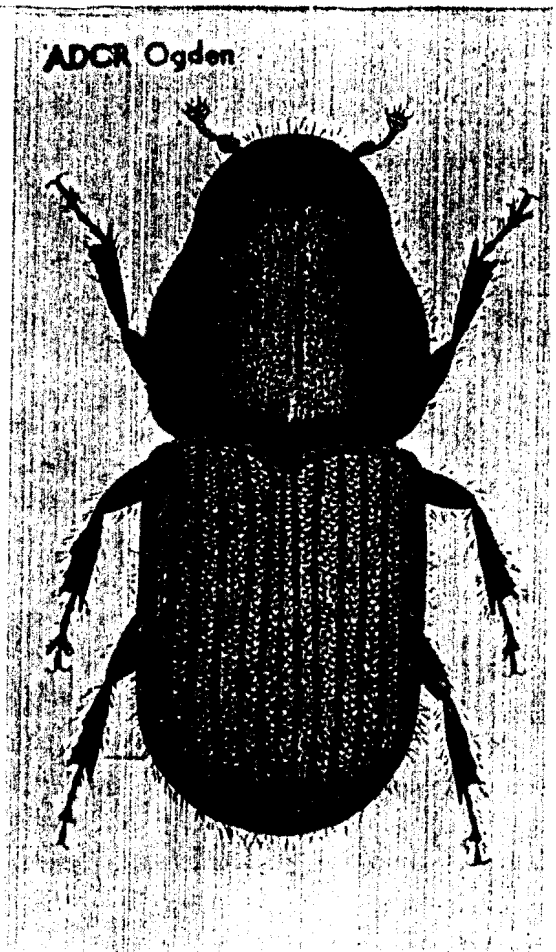
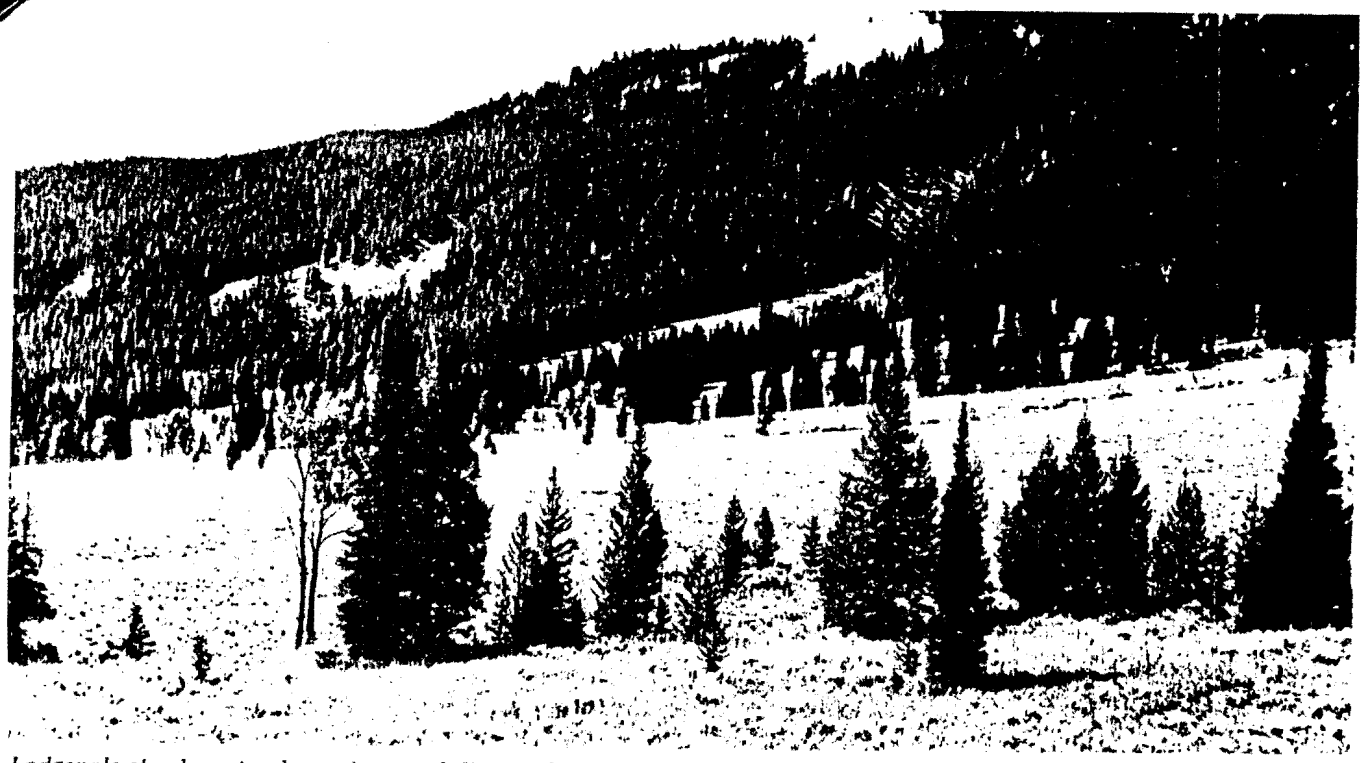
BLACK BEETLES AND GREEN TREES

A Forest Research and Management Problem





Lodgepole stands, natural openings, and dispersed trees form diverse forest environments (Teton National Forest, Wyoming).

Visitors to the lodgepole pine forests that cover millions of acres in Utah, Wyoming, Idaho, Montana, and Nevada expect to find green, healthy stands of trees. Instead, the scene often is one of devastation caused by a tiny enemy of lodgepole pine, the mountain pine beetle.

Lodgepole pine is a dominant tree on some 69 million acres of land in the Western United States and Canada. It contributes to the scenic quality of many landscapes, borders hundreds of campsites and trails, helps protect vital watersheds, and is an increasingly important source of lumber and other forest products.

The mountain pine beetle is always present in lodgepole forests. Evidence indicates an infestation existed in the Horse Creek Drainage of Utah Territory over 180 years ago, long before the white man began to explore the Wasatch Mountains. When beetle numbers are relatively small, the quarter-inch, black insect and lodgepole trees coexist rather peacefully. But during a beetle population explosion, which can occur every 20 to 40 years in a given area, hordes of beetles destroy the forest.

Beetles kill ponderosa pine, an important source of lumber, as well as lodgepole. Epidemic beetle outbreaks now are occurring in forests ranging from the Black Hills of South Dakota to California. In "normal" years, the beetle kills millions of trees, but during an epidemic a single National Forest may lose more than a million trees a year.

Infestations can balloon at alarming rates. A Forest Service survey during a major buildup in 1963 showed that one infested tree produced enough beetles to kill six more trees. In the Rocky Mountain States, the beetle destroys more than 5.5 billion board feet of lodgepole and ponderosa pine timber every year.

TELLTALE SIGNS

Attacking beetles leave telltale sawdust in bark crevices or on the ground at the base of a tree. A few weeks after entry, fungi carried by the beetles stain wood blue just beneath the bark. This is a certain indication that the tree has been attacked and killed.

Tree needles begin to fade as early as 3 to 4 weeks after an attack, but the change from healthy green to deep reddish-brown usually is not noticeable until the spring following attack. Needles drop off the tree within 2 or 3 years after the attack.

Mountain pine beetles may attack individual, scattered trees, but more often entire groups of

Lodgepole pine devastated by the mountain pine beetle (Teton National Forest, Wyoming).

trees are killed. Unchecked, group infestations can expand with each new beetle generation, and eventually large areas may suffer extreme losses of forest cover.

THE BEETLE AT WORK

Forest Service scientists and cooperators have conducted extensive research to better understand the pine beetle's lifestyle and relationship to lodgepole pine. The results show that a significant threat will continue, but that effective control measures are possible.

Studies indicate that few lodgepole pine stands in the Intermountain and Northern Rocky Mountain areas are safe from the beetle. Depending upon the characteristics of sites, from 44 to 90 percent of lodgepole stands have experienced or will experience an epidemic. Usually, an epidemic lasts from 6 to 8 years.

Unfortunately, the pine beetle attacks the most healthy, vigorous trees in a lodgepole stand. Because beetles strongly prefer larger diameter trees, losses range from 1 percent of 4-inch diameter lodgepole to 87 percent of trees with 16-inch or larger diameters.

When adult beetles seek new, green trees in which to mate, they search for images of large, dark objects against a light background. This searching behavior helps beetle populations expand, simply because the insects find larger trees with the greatest food supplies.

The flight period lasts from late summer to early fall. Mating occurs after the female bores into the tree. Eggs hatch into small grubs, and the grubs begin to feed on the tree's phloem before hibernating for the winter. Phloem is a complex layer of living wood just beneath the bark through which ingredients of a tree's food supply are transmitted.

In spring, the grubs resume feeding and grow into pupae. By midsummer, new adults emerge from the now-dead tree and fly to living trees to launch a new 12-month beetle life cycle.

Research has shown that, in addition to the number and distribution of large diameter lodgepole, phloem thickness is very important to beetles. If the phloem is thicker than one-tenth inch, beetles can reproduce in numbers sufficient to kill several trees. In thinner phloem, they do not thrive, and in many cases populations decrease.

The specific site of a stand of trees also is important. Beetle survival is much greater at lower-elevation sites. Beetles are less able to withstand the harsh environments at high elevations. Many other factors also influence the amount of loss caused by a mountain pine beetle infestation.

Using data accumulated over the past 14 years on beetle behavior, infestations, and control attempts, scientists at the Intermountain Forest and Range Experiment Station have developed a model of beetle population interaction with lodgepole pine stands. They also have prepared some preliminary management strategies to deal more effectively with the insect.

Open-spaced lodgepole pine borders many favorite camping areas (Challis National Forest, Idaho).

CONTROL METHODS

Natural enemies of the beetle, woodpeckers and several insects, become more numerous when beetle populations are high. They do not, however, provide effective control by themselves.

What about chemical controls? Studies of chemically sprayed and unsprayed infestation areas show that the beetle moved through both types of tree stands in a similar manner, killing about the same amount of lodgepole. Once an epidemic is underway, the physical difficulties of properly applying chemicals often prevent man from gaining on losses caused by the expanding insect population.

In mountain country, the difficulties include steep terrain and lack of access. Finding experienced control personnel, or training new personnel, and the sheer number of infestations often make it nearly impossible to start chemical control programs effectively.

One control possibility is to remove trees before they reach vulnerable sizes, thus eliminating or reducing the potential for beetle epidemics. Because beetle behavior is so closely tied to food supply — large diameter trees with thick phloem — logging the proper trees in a stand would reduce the food supply before the beetle becomes excessively active within the stand.

Pitch tubes and sawdust traces provide evidence that beetles have entered trees.

Grubs resume feeding on phloem after coming out of hibernation.

An estimated 69 percent of all emerging adult beetles come from infested trees 12 inches or larger in diameter, and 89 percent of emerging adults come from trees with 10-inch or larger diameters. Maintaining stands of lodgepole pine with trees no larger than 10 inches in diameter should restrict successful brood production and lessen epidemic potential. Managing lodgepole pine in this manner also should provide a continuous supply of timber, forest cover for recreation and watershed protection purposes, and sound wildlife habitat.

MEETING THE CHALLENGE

Although scientists have developed basic knowledge of beetle biology and several control techniques, there is a great need to integrate beetle control strategies into forest management practices. Existing techniques and knowledge should be perfected through experimentation and testing.

More scientific knowledge is needed of the relation between mountain pine beetle populations and forest stand dynamics to refine trend predictions and more fully understand mechanisms that trigger epidemics. This research should emphasize