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**INSECTS WHICH KILL FOREST TREES: CHARACTER
AND EXTENT OF THEIR DEPREDATIONS AND METH-
ODS OF CONTROL.^a**

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It has been conclusively demonstrated that certain species of insects are the direct or primary cause of the death of forest trees of all ages, and that from time to time they multiply to such an alarming extent that their depredations assume the character of a destructive invasion, which results in the death of a large percentage of the best timber over thousands of square miles.

There are many species of barkbeetles which prefer to attack matured and healthy trees, and there are many examples of whole forests of century-old trees that have perished from the girdling effect of the mines of the beetles, which are extended in all directions through the inner living bark on the main trunks of the trees. Indeed, we find among these bark-boring beetles the most destructive insect enemies of North American forests. Some notable examples of the depredations of these barkbeetles are given below.

The southern pine beetle.—In 1890–1892 a destructive invasion of the southern pine beetle extended from the western border of West Virginia through Maryland and Virginia into the District of Columbia, northward into southern Pennsylvania, and southward into North Carolina. In this area, aggregating over 75,000 square miles, a very large percentage of the mature and small trees of the various species of pine and spruce was killed by this beetle. In many places in West Virginia and Virginia nearly all the pine trees of all sizes on thousands of acres were killed, while shade and ornamental trees within the same area suffered the same as those in the forest. Since 1902

^a Revised extracts from Bulletin No. 58, Part V, Bureau of Entomology, U. S. Department of Agriculture, 1909.

this barkbeetle has been more or less active in the Southern States from Virginia to Texas, and in some localities and during certain years it has killed a large amount of timber. Records of extensive destruction of timber in the Southern States are found dating back to the early part of the nineteenth century. This species may be considered one of the most dangerous insect enemies of southeastern conifers and, therefore, a constant menace to the pine forests of the Southern States.

The eastern spruce beetle.—During the period between 1818 and 1900 there were several outbreaks of the eastern spruce beetle in the spruce forests of New York, New England, and southeastern Canada. This species caused the death of a very large percentage of the mature spruce over an area of thousands of square miles. In the aggregate many billions of feet of the best timber were destroyed. The larger areas of this dead timber furnished fuel for devastating forest fires, with the result that in most cases there was a total loss.

The Engelmann spruce beetle.—The Engelmann spruce beetle, with habits similar to the eastern spruce beetle, has from time to time during the past fifty years caused widespread devastations in the Rocky Mountain region to forests of Engelmann spruce, in some sections killing from 75 to 90 per cent of the timber of merchantable size.

The Black Hills beetle.—One of the most striking examples of the destructive powers of an insect enemy of forest trees is found in the Black Hills National Forest of South Dakota, where during the past ten years a large percentage of the merchantable timber of the entire forest has been killed by the Black Hills beetle. It is estimated that more than a billion feet of timber have been destroyed in this forest as the direct result of the work of this beetle. This destructive enemy of the western pine is distributed throughout the forests of the middle and southern Rocky Mountains region, where, within recent years, it has been found that in areas of greater or less extent from 10 to 80 per cent of the trees have been killed by it.

The mountain pine beetle and the western pine beetle.—The sugar pine, silver pine, western yellow pine, and lodgepole pine of the region north of Colorado and Utah, westward to the Cascades, and southward through the Sierra Nevadas are attacked by the mountain pine beetle and the western pine beetle, and, as a direct consequence, billions of feet of the timber have died. In one locality in northeastern Oregon it is estimated that 90 to 95 per cent of the timber in a dense stand of lodgepole pine covering an area of 100,000 acres has been killed within the past three years by the mountain pine beetle. Through many sections of the sugar-pine districts of Oregon and California, as the result of attacks by this same destructive barkbeetle a considerable percentage of the largest and best trees is dead.

The Douglas fir beetle.—The Douglas fir throughout the region of the Rocky Mountains from southern New Mexico to British Columbia has suffered severely from the ravages of the Douglas fir beetle, with the result that a large percentage of dead timber is found, much of which will be a total loss.

Three other species of beetles, having destructive habits similar to those above mentioned, depredate on the pines of New Mexico and Arizona, and still another has contributed greatly to the destruction of the larch throughout the northeastern United States and southeastern Canada.

The hickory barkbeetle.—Within the past ten years the hickory barkbeetle has caused the destruction of an enormous amount of hickory timber throughout the northern tier of States from Wisconsin to Vermont and southward through the eastern Atlantic States and into the Southern States as far as central Georgia.

The larch worm.—There are also many examples of widespread depredations chargeable to insects which defoliate the trees, thus contributing to their death. Notable among these are the depredations by the larch worm, which, during several extensive outbreaks since 1880, has killed from 50 to 100 per cent of the mature larch over vast areas in the northeastern United States and southeastern Canada. It is evident that the amount of merchantable-sized timber that has died as the result of defoliation by this insect will aggregate many billions of feet.

CONTROL OF BARKBEETLES WHICH KILL TREES.

The barkbeetles which kill trees attack the bark on the trunk and destroy the life of the tree by extending their burrows or galleries in all directions through the inner living bark. The broods of young grubs or larvæ develop within the inner bark, on which they feed. Those of some species develop to the adult stage within the inner bark and are exposed when the bark is removed, while those of other species transform to the adults in the outer corky bark and the larvæ are not exposed when the bark is removed. Some species have two or more generations in a season or annually, while others have but one, and in a few species it requires two years for a single generation to develop.

The barkbeetles of the genus *Dendroctonus* represent the most destructive enemies of the principal coniferous tree species of American forests, and at the same time are among the easiest of control. The general requisites for success are embodied in the following rules:

(a) Give prompt attention to the first evidence of a destructive outbreak, as indicated by an abnormal percentage of yellow or red topped dying trees, and especially when such trees occur in groups of ten or more or cover large areas; (b) secure authentic determination

of the particular species of insect responsible for the trouble; and (c) take prompt action toward its control according to specific expert advice, published or otherwise, on the best method for the destruction of the necessary 75 per cent or more of the insects in the infested trees.

Some of the methods to be adopted to meet the requirements of various local conditions are as follows:

(1) Utilize the infested timber and burn the slabs during the period in which the broods of the destructive beetles are in the immature stages or before the developed broods emerge from the bark; or

(2) Fell the infested trees and remove the bark from the main trunk and burn the bark if necessary;^a or

(3) Remove the infested bark from the standing timber and burn the bark when necessary;^a or

(4) Immerse the unbarked logs in ponds, lakes, or streams, where the bark will remain soaked long enough to kill the insects; or

(5) Remove the unbarked logs or products to a locality where there are no trees liable to attack within a radius of 20 miles or more.

MAINTAINING CONTROL OF BARKBEETLES.

Future trouble of a serious nature from barkbeetles which kill trees can be prevented within a given forest or area of greater or less extent if an insect-control policy is adopted in connection with, or independent of, a fire-control policy by which groups of dying trees will receive similar prompt attention as that required for the prevention or control of forest fires.

In state and national forests.—In all forest reserves in which there is an organized force of rangers and fire wardens or patrols each officer should be furnished with instructions for the location of beetle-infested trees, and with equipment and directions for taking the necessary action whenever the conditions demand or warrant it.

In private forests.—Private forests should receive the same attention as public forests, but this is often far more difficult on account of intervening forests where the owners either can not or will not give the matter the required attention. While it may be advisable to have some laws to govern the treatment of timber infested with a dangerous pest when the owner refuses to take any action, such a law should apply only to the more extreme cases or as a last resort on authoritative advice. It is probable that in most cases legislation will not be necessary, and more ultimate good will result without than with strict laws, especially when it can be made clear to the

^a If the broods develop to adults in the outer bark, it must be burned; if they develop in the inner bark and are exposed when the bark is removed, burning is not necessary. As a rule the burning of the tops to destroy the insects is not necessary.

owner that his personal interests demand that he take the proper action and that, when necessary, his neighbors will render assistance, as is done in the case of a forest fire.

Inaccessible areas.—There are yet large inaccessible areas in the East and West where it is not practicable or possible at present to control the depredations by these beetles and which must therefore be left to the same natural adjustment that has been going on in all forests from their beginning. While under such natural control much of the older matured timber will be lost it will usually be replaced by young growth, either of the same species of trees or of a different species, so that under normal conditions the forest will be perpetuated; but under exceptional conditions and combinations of detrimental influences, such as secondary insect enemies, fire, and drought, extensive areas may be completely denuded, never to be reforested under natural conditions. Therefore it will evidently not be very long before it will pay to adopt insect-control policies even in the areas that are inaccessible for profitable lumbering.

EXAMPLES OF SUCCESSFUL CONTROL OF BARKBEETLES.

The practicability of the advice based on the results of recent entomological investigations is demonstrated by a number of examples of successful control of depredations by destructive barkbeetles.

CONTROL OF THE EASTERN SPRUCE BEETLE.

The control of an alarming outbreak of the eastern spruce beetle in northeastern Maine in 1900 and 1901 was effected by the concentration of regular logging operations into the areas of infested timber and placing the logs in lakes and streams and driving them to the mills on the Androscoggin River. Thus, with little or no additional expense, there was a saving to one firm, according to its estimates, of more than \$100,000.

CONTROL OF THE HICKORY BARKBEETLE.

The complete control of the hickory barkbeetle, which threatened the total destruction of the hickory trees on Belle Isle Park, at Detroit, Mich., in 1903, was effected by felling and removing the infested trees and converting them into merchantable products, all without cost to the park commission.

CONTROL OF THE BLACK HILLS BEETLE.

An extensive outbreak of the Black Hills beetle in the vicinity of Colorado Springs, Colo., in 1905-6, which was threatening the living pine timber of the entire section, was brought under control through the efforts of the private owners of forests and those of forest officials in the adjoining National Forests. It was accomplished by

cutting and barking about 1,000 beetle-infested and beetle-killed pine trees. The cost of the operations was largely, if not entirely, covered by the utilized felled timber, although there was considerable unnecessary expense involved through the felling and barking of trees from which the beetles had emerged and from the unnecessary burning of the bark and tops.

The successful control of another serious outbreak of this beetle, in 1906, on an extensive private estate in southern Colorado, was effected through the efforts of the owners, who had some 500 infested trees felled and barked within the necessary period to destroy the broods. A large percentage, but not all, of the infested timber was thus treated. These operations were so successful that not a single infested and dying tree could be found when the area was inspected in 1908. In this, as in the other case, considerable unnecessary expense was involved in the burning of the bark and tops, but the value of utilizable timber was probably more than enough to pay all expenses. It is evident that in this case a destructive invasion was prevented.

The practicability of controlling this most destructive enemy of the pine timber of the central Rocky Mountain region, not only without ultimate cost but at a profit on the operations, was demonstrated on a large private estate and the adjoining Pike National Forest in north-central Colorado. An examination of the timber on this estate in the spring of 1907, by a ranger detailed from the Forest Service to work under instructions from the Bureau of Entomology, showed that the depredations by the beetle had been going on for the past ten years or more and had resulted in the death of the choicest timber to the extent of more than 800,000 board feet. About 65,000 board feet of timber was found to be infested by the beetle at the time of the examination. The owner was notified by the Bureau of Entomology of the dangerous character of the infestation and the required action for its control was recommended, but no action was taken. Another examination of the property was made in the fall of 1907, when it was found that the new infestation resulting from swarms of beetles that had been allowed to emerge from the old infested trees involved nearly four times as much timber, or 240,000 board feet. This alarming increase led to the prompt adoption of the recommendations by the owner and the Forest Service, and by May of the following spring (1908) the small number of trees on the National Forest was cut and barked, to kill the insects in the inner bark, and the 1,000 trees on the private estate were felled, the logs converted into lumber, and the slabs burned, which accomplished the desired purpose of destroying the broods of the beetle. The owner realized a sufficient revenue from the timber thus involved to cover all expenses and leave a net profit of over \$1,200. Examination of the area in the fall of 1908 showed that this prompt and properly conducted effort to con-

trol the beetle was a complete success. Thus the average death rate of some 100,000 feet of timber annually during the past ten or more years was reduced to a minimum, at a net profit on the cost of doing it.

In addition to infested trees disposed of by the Forest Service in timber sales, 165 infested trees in one section of the Las Animas National Forest were cut and barked in May and June, 1908, at a direct cost of \$177.50, and at the same time a considerable amount of infested timber was disposed of by sale in the Wet Mountains section of the San Isabel National Forest. This had a decided effect in checking the ravages of the beetle in both of these forests and it was followed up in the latter forest the next spring (1909) by the proper disposal of over 1,000 infested trees by free use, ranger labor, and direct expenditure of funds appropriated by the Forest Service. According to the forest supervisor's report, 80.7 per cent of the infested trees were treated, ranging from 70 per cent to 92.5 per cent on the five units of infestation; 795 trees were treated (535 barked, and 260 felled and bark scorched) at the expense of the Forest Service, including salary and expenses of rangers. The cost per tree was about 60 cents for felling and barking, and ranged from 52 to 78 cents for felling and scorching the bark on the infested trunks. The average cost per tree was 68.2 cents. Six hundred and twenty-six trees were treated by temporary labor, at an average cost of 61 cents per tree under contract at \$1.50 to \$2 per hundred feet in length of trunk peeled. The same rate was allowed for scorching the infested bark instead of removing it. Two hundred and seventy-five trees were treated under administrative use without cost to the Forest Service.

In September, 1909, a very thorough examination was made of the timber in and adjacent to the areas involved in the control operations, and it was found that the thorough, prompt, and proper manner in which the instructions of the Bureau of Entomology were carried out in this case resulted in bringing the beetle under complete control. Only 7 trees had been successfully attacked by the beetles which had emerged from some 400 infested trees which were not cut during the previous control operations. Over 100 trees were found that had been attacked by the beetles, but, owing to the limited number of the latter, the trees were able to resist them and recover.

It is now evident that the control operations carried on in southern Colorado during the past three years, on the Trinchera estate near Fort Garland in 1906, in the Las Animas National Forest and Wet Mountains section of the San Isabel National Forest in 1908, and the more extensive work in the latter area in 1909, had a far-reaching effect in bringing the Black Hills beetle under control within the forested areas of southern Colorado, and that the loss of timber

from this source, amounting to an average of some 300,000 board feet annually, has been reduced to a minimum.

These results mark the most important events in the control of forest insects in this country and serve as striking demonstrations of what can be accomplished when cooperative efforts are directed along the proper lines and based on the results of scientific investigation. The attainment of these results was due to three important factors: First, a knowledge of the insects on which the recommendations by the Bureau of Entomology were based; second, a knowledge of local conditions and requirements and of the habits of the insects in relation to newly infested trees, which enabled a forest ranger to locate the infested trees and give instructions to the forest officials in regard to such locations and the essential details in the recommendations; third, a prompt and proper practical application by the Forest Service of the recommendations according to improved forestry methods to meet the requirements of a forestry problem.

Ten years ago it would have been absolutely impossible to have accomplished this result, owing to the utter lack of knowledge of the first two of these features, and at the present time it would have been impossible without the assistance of the Forest Service.

CONTROL OF THE MOUNTAIN PINE BEETLE.

A very threatening outbreak of the mountain pine beetle was located, in 1909, in the Snowy Mountains section of Montana, adjacent to and within the Jefferson National Forest, involving, at the time, more than 1,500 infested and dying trees. The infestation included timber on the National Forest, public domain, state lands, and private lands, thus involving a complication of federal, state, and private interests with which to deal in securing the required action. The case was so successfully managed that an agent of the Bureau, Mr. Josef Brunner, was placed in complete charge to carry out the recommendations and instructions of this Bureau, and, through the aid of the Forest Service, state officials, and private owners, 1,355 infested trees were cut and barked to kill the broods of beetles. The cutting was started about June 15, 1909, and was completed about July 24 of the same year. Four hundred and twenty-two trees were cut at private expense, 783 at the expense of the Forest Service, and the remainder by local owners. The average cost for felling and removing the bark from the infested portion of the trunk was 30 cents per tree.

Early in December, 1909, a careful examination was made of the area for evidence of new infestation. It was found that, while some 56 trees had been attacked by the mountain pine beetle, the broods were being destroyed by woodpeckers and other natural enemies, and that, therefore, the efforts to control the beetle depredations were a complete success.

The examples of practical control given above have demonstrated at least two important facts: One, that extensive outbreaks by two of the most destructive bark-beetle enemies of the pine timber of the Rocky Mountain forests can be controlled at moderate expense when the timber is not accessible for utilization, or at a profit whenever the conditions are favorable for the utilization of the infested timber; the other, that the essential details of the recommendations and expert advice, based on the results of scientific research, can be successfully applied by a manager of a private forest or by the rangers of national and state forests. Furthermore, these results indicate quite conclusively that the widespread depredations in the Black Hills National Forest could have been prevented with very little expense to the Government if the matter had received prompt attention in 1901, when the first investigations were made and essentially the same recommendations submitted as in the cases mentioned. Failure to do so was through the lack of public appreciation of the importance of the problem at the time and the lack of sufficient authority and funds later. Therefore the outbreak was allowed to extend beyond practical control, and in consequence a large percentage of the timber of the entire National Forest has been killed. There were then no forcible examples of the practical value of recommendations based on scientific research, and no other argument was effective in arousing public interest in the threatening character of the outbreak or confidence in the advice and methods of control. Now that the practicability of controlling the most destructive insect enemies of North American forests has been demonstrated, this should lead to a more general interest in the subject and confidence in the results of scientific research as a basis for success in practical application.

Approved:

JAMES WILSON,
Secretary of Agriculture.

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