

# CONTROL OF BARK BEETLES ON THE NATIONAL FORESTS<sup>1</sup>

BY JOHN F. PRESTON

*U. S. Forest Service*

Tree-killing insects of various kinds are always found in forests; they always have been and always will be present. The bark beetles are most destructive and are almost the only ones for which practicable means of control have been worked out. The genus *Dendroctonus*, including a great many species, has perfected a finesse of operation both remarkable in efficiency and amazing in destructiveness. It is this genus which so far has caused the heavy losses and with which the following discussion deals.

## *Classification of Insect Work:*

Entomologists classify the status of insect attacks at any given time as endemic and epidemic. The first term means a normal number of bug-killed trees in the forest or an annual loss in virgin forests which may be expected and which does not ordinarily justify attempts to stop the damage. It may be expressed as a condition where the balance of nature is undisturbed—where the natural enemies of the bugs (parasites and predators) hold the number of bark beetles to a point where losses are at a minimum.

Under such conditions, there is no possibility of preventing severe losses except through the adoption of artificial control measures which, because of the expense, practical entomologists, except in some cases where timber values are very high, do not recommend. Under usual conditions in the National Forests, the cost of such control would be greater than the value of the timber saved.

Epidemic attacks on the other hand are those where the losses are greater than normal, where, for some reason which we do not yet understand, the balance of nature has been disturbed and the natural enemies of the bugs are no longer able to hold them in check. They consequently fly at will and often kill enormous quantities of timber. Under such conditions there is no alternative to artificial control of the insects except to take very severe losses. Sometimes other classifications are used to indicate the status of the attack, such for example as balanced epidemic where the losses from one year to the next are about equal, or increasing epidemic where losses are increasing.

---

<sup>1</sup>The author wishes to acknowledge the valuable assistance rendered by F. P. Keen and James C. Evenden, entomologists in the Bureau of Entomology in the preparation of this article.

*Cycles:*

Experience indicates that bark beetle epidemics go by cycles and that sooner or later every epidemic will run its course and the number of beetles will be reduced to an endemic status. The length of the cycle can not be foretold and neither can the probable loss. We know that one famous infestation in the Black Hills of South Dakota ran its course in about ten or twelve years, others are known to have lasted longer and shorter periods. The factors which determine the course of an infestation are not now definitely known. Apparently one important factor is the continuity of the timber body of the species suitable as a host. Frequently the new generation of beetles moves out of the immediate vicinity of the killed trees leaving a certain percentage of the trees untouched, perhaps in an effort to escape from their enemies. As long as unworked timber remains adjacent to the original epidemic area there is danger of continued spread. Other factors, of course, have great influence and any number of cases could be cited where the epidemic subsided with abundance of suitable untouched territory adjacent. Perhaps weather conditions have something to do with it and it is reasonable to suppose that they do, but there is little direct evidence so far to prove it. Mr. F. P. Keen of the Bureau of Entomology believes that there is some evidence to indicate that the altitudinal range of the tree species has a bearing on the problem; that the beetle is sometimes able to successfully attack only trees above or below certain contours where presumably the species is outside its *optimum* habitat and consequently its powers of resistance are weakened. Incidentally, if this theory proves to be correct, it may help to establish one limiting factor governing the occurrence of species and forest types—a problem which has given rise to many theories among foresters.

*Life History:*

The life history of all species of *Dendroctonus* is quite similar. The mature beetles, which emerge through the bark from the host trees, fly usually a comparatively short distance and bore into live trees of the same species as the host tree. It would appear from evidence in the field that the normal habit is for the beetles to fly short distances, not over a half mile, and usually not to exceed a few hundred yards. If the number of beetles attacking one tree is not sufficient or the tree is unusually resistant, enough pitch is exuded in the entrance hole to overcome and kill the beetles and the tree lives. However, the beetles have an uncanny way of attacking in force and few individual trees are

successful in defense. Once inside the bark next to the cambium the adult beetle digs a channel and lays eggs at intervals along it. In most cases the mating of male and female takes place under the bark. At any rate both male and female enter the tree and both assist in the housekeeping operations, consisting of throwing out sawdust and preparing ventilating holes through the bark. After the egg laying, the adult beetles have pretty generally completed their life task and either die immediately or in a few months. The eggs hatch shortly into white grubs and begin digging channels in the cambium usually at an angle to that of the parent beetle. The grub grows as it works, fattening upon the life tissues of the tree and together with the work of the parent successfully girdles the tree and causes its death. When the grub or larva is fully grown, it transforms into the pupa or quiescent stage which in turn shortly develops into the adult or beetle. When finally matured it digs an exit hole, or uses one prepared by another beetle, and repeats the destruction of its parent, augmented under epidemic conditions by greatly increased numbers.

The Black Hills beetle (*Dendroctonus ponderosae*) has only one brood a year and lives entirely in the cambium under the bark. *Dendroctonus brevicornis* on the other hand has several broods each year and lives *in* rather than *under* the bark. Many other minor variations occur in the life histories of the different species.

#### *Recognizing Epidemic Conditions:*

It is obviously of the utmost importance in the protection of the forest, for the local forester to be able to recognize the change in the status of the insect attack from "endemic" to "epidemic." The former condition usually calls for a policy of "watchful waiting" while the latter calls for an immediate report and action of some sort. As explained later whether or not it means actual control work depends upon the value of the timber being destroyed. Actually, entomologists are considerably "at sea" as to just what constitutes endemic and epidemic conditions and it is impossible to define exactly the point where the former leaves off and the latter begins.

From the practical viewpoint of forest protection, the exact line is not important. The "Forest Officer in charge" must determine the point where in his judgment the losses of timber are sufficiently noticeable to be alarming. Systematic observation of the same territory from year to year is usually sufficient to arouse suspicions or to allay fears. Occasional trees killed widely scattered throughout the forest is perhaps

the usual criterion of an endemic attack and need cause no alarm. It is necessary to arrive at this definition of endemic status for each separate forest and set of conditions. It is apparently not the same everywhere and certainly varies with each species of bark beetle. The local forester must take advantage of past experience by studying his forest for records of former attacks and he must, of course, seek the advice of experts whenever opportunity presents itself.

Any increased activity of the insects as shown by more frequent occurrence of infested trees and particularly a tendency to group infestation is the signal of danger and calls for an investigation. "The sudden springing up of newly infested trees, either singly or in small groups all over the forest, usually indicates an increase in the infestation."<sup>2</sup> All bark beetle epidemics do not show as increasing infestation from a center, usually known as the group method of attack, but where it does occur in this form, it is usually a sure indication of the epidemic status. This criterion may be used in the case of *D. ponderosae* and to some extent in attacks of *D. brevicornis*, but I understand it is quite infrequent in the over-wintering generations of the latter species. According to Mr. Evenden, the group attack is no indication of an epidemic in the case of the mountain pine beetle (*D. monticolae*). The best criterion, therefore, is the local forester's judgment that the number of infested trees indicates a rapid or abnormal increase irrespective of the occurrence of the infested trees in groups. Where they occur, the groups, in the worst epidemics such as that now existing in the Kaibab National Forest, often merge until nearly solid bodies of timber covering several hundred acres are killed.

#### *Scouting:*

One of the most important things to be done when epidemic insect conditions are found is to scout the territory to determine the extent of the attack. No man successfully fights a forest fire without finding out the size of the fire, the conditions in and surrounding it and where it is headed. Exactly those same facts must be determined for every insect epidemic before successful control can be inaugurated. The line of demarcation between the epidemic and the endemic stages must be established and the status of the epidemic area—that is, where it is increasing and where balanced and where heavy concentration occurs.

Every forester or forest ranger, or whatever his title may be, who is responsible for that particular forest property must become sufficiently

<sup>2</sup>Quotation from a letter received from J. C. Evenden.

familiar with the threatening attack to do this scouting. This is just as important in the protection of the property as is fire patrol. It requires some skill and experience and knowledge of the habits of the different species of *Dendroctonus* to spot the newly infested trees early in the season, but later on as the trees begin to die, the needles fade and gradually acquire sorrel or red tops. It is then too late, as a rule, to start control operation that season but the evidence is plain upon which to base a plan for control for the following season. The increase from year to year is plain and only awaits a systematic cruise to properly interpret the evidence.

#### *Methods of Checking:*

The forest officer, suspicious of the insect enemy should set about collecting evidence just as he collects evidence of any other form of trespass. Strip lines are run through the timber usually from 5 to 10 chains wide along which the losses of the past year and the current year are recorded. The same lines re-cruised for several seasons will tell the tale. In rapidly increasing infestations, one year's tally may be sufficient to establish the presence of the enemy and the need for immediate action. The strip lines, supplemented by thorough scouting, will furnish the information, in terms of number and sizes of trees attacked and of the total epidemic area, upon which to estimate the cost of control. The secret of success in insect control, as in fire protection, is to catch the damage in its early stages.

The Bureau of Entomology of the Department of Agriculture cooperates with the Forest Service and with private owners in the examination of infested areas and its experts furnish advice as to the cost and feasibility of control. The personnel of this Bureau, however, is limited and no forest owner can afford to wait for advice until the seriousness of the situation is forced to his attention by casual observation. Too often in the past when the entomological doctor was called in, the patient was in a serious condition, necessitating a major operation. Often too, the forest owner was in no financial condition to bear the expense of the operation and there was nothing to do but allow the patient to die. Home remedies applied early would have checked the destruction and prevented tremendous losses. There is no other way to successfully protect forests from insects. The responsible forest officer must continually be on the alert and able to diagnose the case, at least sufficiently to become aware that he needs expert advice.

*Difficulties of Control in the National Forests:*

The Forest Service has made some progress in detecting and stamping out incipient epidemics but too often they have assumed alarming proportions before being recognized. It is now fighting an epidemic in the Kaibab National Forest and the Grand Canyon National Park which covers over a hundred thousand acres. Failure to read the signs in the woods back in 1919 and 1920 and failure to scout and collect the evidence in that early stage has probably caused the loss of not less than 100,000 M feet of yellow pine and the expenditure of \$50,000 in the attempt to stop the steady march of the army of destruction.

The reasons for the failure in this case, as in others, are many. Primarily, it is because forest officers have too often passed up protection against insects as something beyond their ken. They have become accustomed to seeing insect infested trees and are too prone to accept them as a necessary evil. They have failed to recognize that it was their job to distinguish between endemic and epidemic conditions and to take steps to stop the damage at a time when it could be accomplished at a relatively low cost. As a corollary of this situation it may be noted that the National Forests have been inadequately manned with trained foresters really competent to read the signs. Appropriations have not kept pace with the increasing intensity of management with the result that the Service has not been able either to employ in the field a sufficient force of trained men or to give the necessary training to much of the excellent material it has in its ranger force.

Several hundred thousand acres in charge of one forest officer can not be watched with the eagle eye which the value of the property justifies. In spite of all the care he can give, the insects may and often will get the upper hand before he realizes it. A great deal more could and must be done, however, by a changed attitude and an understanding of the responsibility involved, if the National Forests are to be saved from heavy losses.

An epidemic extending over several hundred thousand acres in the Missoula, Flathead, and Helena National Forests has been in progress for the last 15 years and shows no signs of abatement. The job of control is so big and the values at stake so small that very little can be done to hold it in check. The infestation must run its course. The epidemic of *D. brevicomis* in southern Oregon has been in progress for more than ten years and about \$250,000 has been spent in the last three

years by private, State and Federal agencies in its control. The time to stop insect losses on a practicable scale is in the early stages, and it is the forester's job to recognize the epidemic stage or at least the dangerous symptoms of it.

#### *Methods of Control:*

The felling of the infested trees and the destruction of the insects while in the larva, pupa, or adult stage before flight, is the means adopted for controlling infestations. There is no way to save individual trees once attacked in force by the beetles. The method is aimed solely at destroying the broods while in the process of development in order to prevent the flight. Simply peeling the bark and exposing the insects to the sun and air while in the immature condition is sufficient to kill the Black Hills and the mountain pine beetles. Because they are found in the bark rather than under it, it is usually necessary to burn the bark of trees infested with *Dendroctonus brevicomis*. It has been found that exposure to direct sunlight where summer temperatures are high is sufficient to kill the broods of the latter insect but the period during which high temperatures prevail is so short and so uncertain that this method has not been used extensively. The method of control for each insect is adapted to its life history and the advice of an expert on this point should always be sought before beginning control operations.

#### *The Percentage Theory:*

The underlying idea in all artificial control measures is to reduce the number of beetles to a point where their natural enemies can hold them in check. In other words, to restore the normal balance of nature at once rather than wait for the infestation cycle to run its course and stand the loss which that entails. Dr. Hopkins<sup>3</sup> evolved what he called the percentage theory of control. His studies indicated that destruction of only a part of the beetles, leaving a sufficient number to feed the parasites and predators was more beneficial than the attempt to destroy a larger number. Complete destruction of all insects is a practical impossibility, so that it is merely a question of attempting to destroy 60 or 75 percent or 95 percent. The method outlined by Dr. Hopkins was to cut 60 or 75 percent of the infested trees on *all* parts of the epidemic area and leave to the parasites and predators the completion of the job.

One unfortunate feature of all artificial control work is that in destroying the beetles large numbers of their parasites and predators

<sup>3</sup>Dr. A. D. Hopkins, formerly chief of the Division of Forest Insects in the Bureau of Entomology and pioneer in the study of bark beetles.

are also destroyed, and it was in the attempt to encourage the multiplication of natural enemies of the beetles that Dr. Hopkins advocated the felling of not over 75 percent of the infested trees.

The control work carried out in the National Forests during the past few years has shown that the practical application of this theory is fraught with many difficulties. The results of attempts to leave part of the beetles (a percentage over the entire infested area) has not, as a rule, given satisfactory results. In the Kaibab work, areas where control was carried out in accordance with the percentage theory were heavily infested the following season, and on areas where the attempt was made to cut all infested trees there resulted very little new infestation the following season. I understand that similar results have been obtained on other control projects. On the other hand, some control projects carried out strictly in accordance with the Hopkins theory have apparently been successful. The Bureau of Entomology representatives in the western work now apparently agree that the surest way is to make just as clean a sweep as possible and to follow up the first control with maintenance work for one or more succeeding seasons. They emphasize more and more the importance of maintaining the ground gained, and preventing by artificial means at a time when control is cheap, the gradual rise of the infestation to epidemic proportions.

#### *The Kaibab Theory of Control:*

The rapid spread of the epidemic of the Black Hills beetles on the Kaibab National Forest from 1923 to 1924 and the consequent total inadequacy of the available funds to clean up the infestation together with the uncertainty of future appropriations, has necessitated the adoption of a plan which may give rise to a new theory or a modern adaptation of the old Hopkins theory. The peak of this epidemic is at the north end of the Forest where the beetles have moved from the mixed type of forest into pure pine. In this region the number of infested trees found varies from a few hundred to over 3,000 per square mile. The destruction here over considerable areas is nearly complete and the tremendous increase during the past year certainly gives no promise of a quick ending of the cycle without artificial control. Studies of the infestation farther south where the epidemic conditions have prevailed for several seasons indicate that the insects are less rabid here than at the extreme north end and give some hope that the peak has already passed and that the natural

enemies of the beetles will be able to check the destruction. Mr. Keen of the Bureau of Entomology, who is in charge of technical strategy of the work, advances the theory that the most husky and daring members of the tribe are the pioneers and these make the inroads into new territory, leaving the sluggards and less husky individuals to mop up in the rear. His theory is that since we haven't enough money to make a clean sweep of the entire area there is an opportunity to hit a death blow to the pioneers on the front line and trust to the parasites and predators to subdue the rear.

The plan of attack is, therefore, to make a clean sweep of 14,000 or 15,000 acres at the north end and extending south and west in a strip two miles wide. If results seem to justify this strategy, maintenance control will be carried out in succeeding years in the same area to catch and subdue the advance guard and prevent it from crossing the frontier or dead line thus established. If it succeeds, control will be cheaper than any attempt to sweep clean the entire epidemic area but the timber losses will be heavier. However, on this Forest which is located on the north rim of the Grand Canyon the commercial value of the trees is very low and does not justify expensive control measures. It will be seen that this theory is fundamentally the same as the one originally proclaimed by Dr. Hopkins, but the application of it is vastly different.

#### *When is Control Justified?*

Artificial control is always justified when the job is small and the epidemic is increasing. When the epidemic has already covered large areas before the seriousness of the situation is realized the advisability of control work will hinge on the question of values—the cost of control as against the timber values to be saved. Usually where the job is big, the epidemic has already reached a peak before control operations begin and will surely decline in the future. Control operations have recently cost from \$3.00 to \$5.00 per M feet for the trees actually felled. Such work has undoubtedly reduced the annual loss to one-half of what it would have been without control. Figuring the average epidemic cycle at ten years, it could be figured to run another five years after the peak, or five years' losses at the current rate could be used to estimate the probable loss without control. If the current loss is 200 board feet per acre per year, the loss in five years would be 1,000 board feet. One-half could be saved by control work or 500 board feet. The control at \$5.00 per M feet would cost \$1.00 per

acre; at stumpage values of \$2.00 per M feet the saving in timber would just equal the cost of control without considering the cost of maintenance and the risk of failure. Any stumpage values exceeding \$2.00 per M feet would probably justify control measures. It is purely a question under such conditions of balancing control costs against conservative estimates of timber values to be saved. In general, it may be said that where stumpage values are approximately equal to the cost per M feet of the control work, the timber saved will amply justify the expenditure and where stumpage values are \$2.00 or less, control work can not be justified solely from a commercial viewpoint. Experience has taught the further lesson that it is useless to deal gently with an insect epidemic; it must be hit a good hard blow or the money is wasted. Furthermore, the ground gained must be held just as in fire fighting. Insect control involves the first heavy blow and expenditures on a smaller scale for at least several succeeding seasons until the epidemic is reduced to endemic.

#### *Records of Past Control Work:*

Insect control work has been carried on by the Forest Service on a small scale since 1906, when a few thousand dollars were spent in an effort to stop the infestation in the Black Hills of South Dakota. Until the Fiscal Year 1924 there was no regular appropriation made for this activity and consequently the money had to be obtained by squeezing it from other activities or by special appropriation from Congress. By and large the accomplishment has probably been very small because, in most cases, the blow struck was too feeble. A great deal of valuable experience was obtained however, and the results both negative and positive were worth while experiments from which the Bureau of Entomology has learned much to guide the future work.

Beginning with the Fiscal Year 1924 the agricultural appropriation bill authorized the expenditure of \$25,000 of the fire-fighting fund for controlling insect infestations and this authorization was repeated in the bill for the year 1925. This will enable the Forest Service to take an entirely different attitude toward insect control. Heretofore, it has been forced, through lack of funds, to side-step the insect problem as much as possible. Now it can go after it aggressively in the attempt to prevent large losses rather than simply to save something out of the wreck.

The largest project so far undertaken is the southern Oregon-Northern California project, which was a cooperative effort by Federal,

State and private owners under the technical direction of the Bureau of Entomology and for which Congress appropriated \$150,000 available over a three-year period. The third year's work is now almost completed and the project has been put on a maintenance basis. This belongs to the class of projects previously mentioned where the epidemic had already reached a peak before control work began. For the Kaibab-Grand Canyon project, a special appropriation of \$25,000 was made this year. This is also the third season for this work but at no time has there been available enough money to really strike a telling blow.

Statistics recently compiled of insect control activities of the Forest Service up to and including the calendar year 1923 are shown in the following table:

Calendar Year	Total Volume Treated M. ft. B. M.	Total Amount Expended	Cost per M. ft. B. M. (for treated timber)
1906.....	300	\$2700	\$9.00
1907.....	450	2589	5.50
1908.....	1,000	2500	2.50
1909.....	?	50	?
1911.....	4,284	24452	5.70
1912.....	2,298	15040	6.54
1913.....	7,090	23434	3.30
1913.....	?	446	?
1914.....	6,670	22452	3.36
1915.....	1,959	7939	4.05
1916.....	4,929	10535	2.14
1917.....	4,536	15004	3.30
1918.....	823	2557	3.11
1918.....	355	2502	7.05
1919.....	1,546	9735	6.29
1920.....	4,285	20905	4.88
1921.....	17,622	74082	4.20
1922.....	19,284	68381	3.54
1923.....			
Total.....	77,431	\$305,303	\$3.93
By Districts			
1.....	4,390	\$ 20,475	\$4.55
2.....	2,489	15,079	6.01
4.....	6,563	18,585	2.83
5.....	29,013	103,490	3.57
6.....	34,974	147,674	4.22
Total.....	77,431	\$305,303	\$3.93

#### *Insect Losses:*

It is, of course, very difficult to even estimate the annual loss of timber from insect attacks and any statistics attempted are interesting

rather than useful or accurate. Furthermore, much of the loss is from endemic infestation which can not be controlled under present economic conditions. It is easy to figure an annual loss of not less than 500 million feet on the National Forests which, if given a value equal to that of National Forest timber cut for the last five years, would easily equal or exceed the annual loss from forest fires for the same period. The following paragraph explains the basis for this estimate.

An insect survey was made in California in 1917 by the Forest Service in cooperation with the Bureau of Entomology and the National Park Service covering an area of 1,682,600 acres, mostly virgin forest. This area contained 19,307 million feet of timber or 18 percent of the total timber stand in the State. The calculated loss for that year was 25,570 M feet of yellow and sugar pine amounting to .13 of 1 percent of the stand or about 15 board feet per acre. Mr. J. C. Evenden of the Bureau of Entomology estimated that the loss of white pine on the Coeur d'Alene National Forest in 1918, which was considered to be a subnormal year, was .3 of 1 percent of the total stand. On the basis of a total stand all species of 4,000 million feet on 660,000 acres this would represent a loss of about 18 board feet per acre per year. Mr. J. C. Miller also of the Bureau of Entomology, in his first annual report on the San Joaquin project, Sierra National Forest, gives the annual endemic loss of yellow and sugar pine as .1 of 1 percent of the total pine volume. Mr. A. E. Weislander of the Forest Service in a management plan for the eastern Lassen Working Circle, Lassen National Forest, estimated the loss from insects on the 170,000 acres included in the circle as 50 board feet per acre per year. The total stand of yellow, sugar, jeffrey, white and lodgepole pine and spruce on the National Forests is roughly estimated to be 215,000 million feet. These are the species most subject to insect attack and which have suffered most severely from endemic infestation. At .1 of 1 percent the loss would be 215,000 M feet, or at .2 of 1 percent 430,000 M feet.

#### *The Ultimate Solution:*

A loss of somewhere between \$500,000 and \$1,000,000 annually due to insect depredation on the National Forests would seem to be a conservative estimate. In spite of this enormous loss, it is useless to talk of trying to stop any considerable portion of it. It can not be done; at least no practicable method is known which would not cost more than the timber saved would be worth. The above figures represent largely losses from insects in the endemic status scattered over the

entire belt of National Forest timber throughout the West. We are absolutely helpless before the insidious attacks of this foe and we must pay the annual toll demanded. It is a common saying among foresters that in virgin mature timber, growth is largely offset by decay. Bark beetles are one of the reasons why this is so. While we must be content to pay the annual toll due to endemic insect attacks the same statement does not apply to the epidemics. Where concentration occurs and the gorillas mobilize in force it is practicable to fight back. As already explained, it is then wholly a question of the values at stake.

The timber in the National Forests, is at the present time, still largely inaccessible and of low sale value, and only a very extensive form of management is in effect. When the demand for this timber increases to the point where reasonably intensive management is possible the situation will be different. It is different now in isolated spots and regions. When a field officer has only 50,000 acres to look after instead of 250,000 acres, the job of watching the insects will not only be easier but it will entail little expense for control. The removal of the sustained annual yield will gradually replace the present overmature stands with a growing stock of young timber better able to resist the insects. The annual cutting operations will furnish freshly cut logs to attract and feed the hungry broods whose destruction will usually follow. The elasticity of the cutting program will enable the forester to shift the logging so as to check any threatening epidemics. From present indications, the day of intensive management for our heavily timbered National Forests is not distant more than 20 years.

It is some consolation to know that we will not always have an insect problem comparable to that which we now face. In a well managed and intensively used forest the toll which the insects can take will be very small. Insect species can perhaps never be exterminated, but certainly the waste of timber which they cause can be and will eventually be stopped. Meanwhile it is the forester's job to do what he can to prevent the heavy and spectacular losses and he must not side step the problem. I want to again emphasize the statement that the control of insects is primarily the forester's job; the technique of methods must be prescribed by the entomologist, but the responsibility for the protection of the forest against insects must rest squarely upon the forester's broad shoulders. Will he be able to carry the burden?