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En82C
129



Issued November 25, 1910.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF ENTOMOLOGY—CIRCULAR No. 129.

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INSECTS IN THEIR RELATION TO THE REDUCTION
OF FUTURE SUPPLIES OF TIMBER, AND
GENERAL PRINCIPLES OF CONTROL.

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INSECTS IN THEIR RELATION TO THE REDUCTION OF FUTURE SUPPLIES OF TIMBER, AND GENERAL PRIN- CIPLES OF CONTROL.^a

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In Charge of Forest Insect Investigations.

Insects not only reduce future supplies of timber by killing the mature trees and destroying the wood of timber that is inaccessible for utilization, but through injuries inflicted upon trees during the flowering, fruiting, germinating, seedling, and sapling periods of early growth they prevent normal reproduction and development.

INTERRELATIONS OF FOREST INSECTS AND FOREST FIRES.

Investigations conducted by the writer and assistants in all sections of the country during the past ten years indicate to them quite conclusively that the average percentage of loss of merchantable timber in the forests of the entire country to be charged to insects during a five or ten year period is infinitely greater than most people realize.

Losses from forest insects.—The writer estimates that for a ten-year period the average amount of timber in the forests of the entire country killed and reduced in value by insects would represent an average loss of \$62,500,000 annually.^b

It has been estimated that the Black Hills beetle killed approximately 1,000,000,000 feet B. M. of timber during a period of ten years, which at \$2.50 per thousand would amount to an average of \$250,000 annually. This is merely one example of very destructive depredations by a single species of barkbeetle in a single National Forest.^c

^a Revised extracts from Bulletin No. 58, Part V, Bureau of Entomology, United States Department of Agriculture.

^b *Losses from forest fires.*—It has been estimated that "on the average, since 1870, forest fires have yearly cost \$50,000,000 in timber." (Cleveland, T., jr., Circular 167, Forest Service, United States Department of Agriculture, p. 3.)

^c It has been estimated that the losses of timber from forest fires on all of the National Forests of the United States from 1905 to 1908, inclusive, average only \$165,062 annually. (Cleveland, T., jr., Yearbook United States Department of Agriculture for 1908, p. 541.)

Prof. Lawrence Bruner, state entomologist of Nebraska, at a meeting of the American Association of Economic Entomologists, held at Baltimore, Md., in December, 1908, spoke as follows: "I can agree with Doctor Hopkins that the insects are far more important in destroying our forests than fires."

Insect-killed timber as fuel for fires.—It has often happened that after insects have killed the timber over extensive areas the standing and fallen dead trees furnished fuel for great forest fires which have not only destroyed or charred the dead timber but killed the living timber and reproduction and swept on into adjacent areas of healthy timber. Indeed, abundant evidence has been found during recent investigations to indicate that some of the vast denuded areas in the Rocky Mountains and other sections of the country are primarily due to widespread devastation by insects, and that subsequent fires destroyed the timber and prevented reproduction.

It is also evident that a considerable percentage of dead timber, and especially that found in coniferous forest regions, which has generally been believed to have been fire-killed is a result of primary attack by insects. This has been demonstrated in many cases by the pitch-marked galleries of the destructive barkbeetles on the surface of the wood of the old dead trees which had escaped subsequent fires.

Fire-killed timber injured by insects.—It is true that a vast amount of timber has been killed outright or has died as the direct result of forest fires, but in almost every case observed insects have contributed to a greater or less extent to the death of recently fire-injured trees which might otherwise have recovered, and especially to the rapid deterioration of the wood of a large percentage of the injured and killed trees. It is evident that in some cases fire-scorched and fire-killed timber has contributed to the multiplication of one or more of the insect enemies destructive to living timber, and thus the injury started by the fire may have resulted in a destructive outbreak of beetles. However, it is evident that this has happened only when the destructive beetle was already present in abnormal numbers in the forest surrounding the fire-swept area. Therefore, *it is believed that injuries by fire are not as a rule an important factor in contributing to subsequent depredations by barkbeetles.* Such fires, however, contribute to the multiplication of the insects which deplete on the bark and wood of dying and dead trees, so that in forested areas where fires are frequent the damage to the wood of such trees is more severe, and fewer injured trees recover on account of the abundance of secondary barkbeetle enemies which do not, as a rule, attack and kill living timber.

Destruction of insects by fire.—There is another important feature in the relation of insects and fire, in which the fire contributes to the destruction of the principal barkbeetle enemies of the living timber.

This happens when the fire burns the timber while it is infested, thus effectually destroying the broods of the insects. It is perfectly plain that the dying and dead foliage of the beetle-infested trees and the dead bark on the trunks would contribute to the spreading of crown fires and thus the bark on the entire infested trunks would be sufficiently scorched to kill the insects. Therefore, complete fire control may easily contribute to more extended depredations by insects on the living timber, thus increasing, rather than diminishing, the need for insect control. However, the setting of fires or permitting them to burn for the purpose of combating insects should never be undertaken or permitted.

Durability of insect-killed timber.—Some of the matured larch trees which evidently died as a result of defoliation by the larch worm between 1881 and 1885, and which had escaped subsequent depredations by fire and wood-boring insects, were found by the writer in 1908 to be standing and sound enough to be utilized for railroad ties and many other purposes. Under similar conditions the heartwood of red spruce and white pine in the East, of Engelmann spruce in the Rocky Mountains, and of Douglas fir in the Northwest coast region have been found by the writer to be sound enough for profitable utilization for pulp wood, lumber, fuel, and other purposes from twenty to thirty years after it had been killed by insects or fire. Thus it is shown that timber killed by insects and fire would be available for utilization for many years were it not for injuries through the secondary attacks of wood-boring insects and the destruction of insect-killed timber by forest fires.

INTERRELATION OF FOREST INSECTS AND FOREST FUNGI.

Decay following injury by insects.—It is well known that the burrows in the bark and wood of living and dead trees and in the crude and finished products often contribute to the entrance of bark and wood decaying fungi. Deterioration and decay are thus far more rapid than would otherwise be possible. It is also known that trees injured and dying from primary attack by parasitic fungi are attractive to certain insects which breed in the bark and wood of sickly and dying trees, and that certain other complicated troubles affecting forest trees are the result of an intimate interrelation and interdependence of insects and fungi. There can be no doubt, however, that certain species and groups of both insects and fungi are independently capable of attacking and killing perfectly vigorous and healthy trees.

SUMMARY AND ESTIMATES RELATING TO CHARACTER AND EXTENT OF INSECT DAMAGE.

The killing of trees by insects; the damage by them to the wood of living, dying, and dead timber; the destruction of insect-killed timber by subsequent forest fires; the damage to fire-killed timber

by insects; and the damage from decay resulting from insect injuries to the wood, have all been more or less continuous for centuries and are still going on in the forest and woodland areas of this country.

While these depredations are not always evident or important in all forests or localities, yet almost every year, somewhere in the forests of the country, there are widespread depredations.

In every forest and woodland there is an ever present but inconspicuous army of insects which require the bark, wood, foliage, and seeds of the various tree species for their breeding places or food. Thus, the accumulated but inconspicuous injuries wrought during the period required for the growth of a tree to commercial size go far toward reducing the average annual increment below the point of profitable investments.

The accumulated damage to crude, finished, and utilized products reduces the profits of the manufacturer, increases the price of the higher grades to the consumer, and results in an increased drain on the natural resources.

In any attempt to estimate in *feet, board measure, or dollars*, the extent of losses or waste of timber supplies caused by insects there are many conflicting factors which contribute to the difficulty of arriving at accurate conclusions. The published information concerning the amount in board feet of standing timber in the country is admittedly only an estimate, as are also the published data relating to average stumpage value. The published statistics relating to the amount and value of forest products are of course more accurate, but until more complete data can be furnished by the forest experts on the various complicated phases of forest statistics any figures given by the forest entomologist relating to the value of timber and commercial products destroyed or reduced in value by insects must be considered on the same basis as the other estimates, and as the best that can be presented on available evidence.

Standing timber killed and damaged by insects.—When we consider the amount of standing merchantable timber killed by insects and the amount of standing timber, living, dying, and dead, which has been reduced in quantity and value through their agency during a ten-year period, we would estimate that such timber represents an equivalent of more than 10 per cent of the quantity and stumpage value of the total stand of merchantable timber in the United States at any given time.^a A certain percentage of such timber is a total

^aThe estimate of the area and stand of the present forests of the United States, as given in Circular 166 of the Forest Service, page 6, is two trillion five hundred billion feet (2,500,000,000,000) board measure. The average stumpage value has been given as \$2.50 per one thousand feet b. m., making a total value of the standing merchantable timber of \$6,250,000,000. Ten per cent of this amount would be \$625,000,000, as the amount to be charged to in-

loss because of the impossibility of utilization; but in some cases a greater or less percentage can be, and in some cases is, utilized within the period in which it is of sufficient value to yield a profitable return on the cost of logging and manufacture, although its value is greatly reduced.

Reduction in the Nation's wealth.—When we consider the forest resources both in merchantable timber and young growth as an important asset of the Nation's wealth; as representing a given value to the people for direct utilization; as a cover to the soil for protection of the land from erosion; as protection of headwater streams and of game; and as contributing to the æsthetic value of health and pleasure resorts, it would be difficult indeed to estimate the amount or percentage of loss of timber or the reduction in the land values, in each case, chargeable to insects. It is plain, however, that in the aggregate it is considerably greater than when estimated on stumpage values alone.

Reduction in cash revenue.—When we consider the problem from the standpoint of direct utilization we can estimate the annual loss on a basis of mill values; but here again we meet with complications, since much of the damaged material is left standing or is discarded in the woods or at the mill without measurement. Therefore we are left to judge from our observations and knowledge of the general conditions as regards dead and damaged timber found in the forests of the country, and the information from lumbermen in different sections, as to the percentage of loss from defective timber. On this basis we can estimate that the amount of insect-killed and damaged timber left in the woods, plus the reduction in value of that utilized, to be charged to insects is not far from an equivalent of 10 per cent of the value of the annual output of forest products of all kinds, in the rough. The total value of the forest products of the United States in 1907 is given as \$1,280,000,000; the losses from insect depreciations would therefore represent an annual loss in a cash value of more than \$100,000,000.

Reduction in value of finished and commercial products.—When we consider the aggregate loss to the manufacturers of the finished products, to the trade, and to the consumer from insect injuries to the wood, it is evident that it amounts to many millions of dollars in addition to the estimated loss of crude products, or at least 3 per cent of the mill value.

sects for a ten-year period, or an average of \$62,500,000 annually. As an example, it has been estimated that over 1,000,000,000 feet b. m. of timber was killed by the Black Hills beetle in the Black Hills National Forest within a period of ten years. This, at \$2.50 per one thousand feet stumpage, would be an average of \$250,000 annually in a single forest of 1,294,440 acres.

METHODS OF PREVENTION AND CONTROL.

The results of extensive investigations and of practical applications of the knowledge gained during recent years have demonstrated that some of the most destructive insect enemies of American forests and of the manufactured and utilized products can be controlled, and serious damage prevented, with little or no ultimate cost over that involved in forest management and business methods.

There are, of course, certain insects and certain injuries which, under present conditions and available information, can not be controlled or prevented, but it is very evident that if the information now available through the publications of the Department of Agriculture and through direct correspondence with its experts is properly utilized in the future it will result in the prevention of at least 30 per cent of the estimated annual waste of forest resources that has been caused by insects within recent years, and thus contribute greatly to the conservation of forest resources.

GENERAL PRINCIPLES OF CONTROL.

The ordinary spraying and similar methods employed in dealing with fruit and shade tree insects are, of course, not available for practical application in the case of forest trees. But there are other and less expensive methods of accomplishing the desired results.

In all efforts to control an outbreak or prevent excessive loss from forest insects it should be remembered that as a rule it is useless to attempt the complete extermination of a given insect enemy of a forest tree or forest product. Experience has demonstrated that it is only necessary to reduce and weaken its forces 75 per cent or more. It can not then continue an aggressive attack, but must occupy a defensive position against its own enemies until conditions resulting from avoidable negligence and mismanagement by the owners of the forests and manufacturers of forest products favor its again becoming destructive. Forest insects can thus be easily kept under control by good management.

The desired control or prevention of loss can often be brought about by the adoption or adjustment of those requisite details in forest management and in lumbering and manufacturing operations, storing, transportation, and utilization of the products which at the least expenditure will cause the necessary reduction of the injurious insects and establish unfavorable conditions for their future multiplication or continuance of destructive work.

It is, however, of the utmost importance that any adjustment or modification in management or business methods should be based on

expert technical knowledge or advice relating to the species, habits, life history, and natural enemies of the insects involved and the essential features of the methods for their control. This should be supplemented by expert knowledge or advice on the principles of technical and applied forestry in the proper management, care, and utilization of the forest and its resources, and still further supplemented by practical knowledge and experience relating to local conditions and facilities favorable and unfavorable for success in practical applications according to the recommended method or policy of control.

As has been shown, the mature or merchantable timber is the most susceptible to injury or death from the ravages of insects. Therefore, considered from the standpoint of insect control and the prevention of one of the greatest items of loss, it is important that such matured timber should be utilized before it begins to deteriorate, or before it reaches the stage of unprofitable growth.

For the greatest success in dealing with forest insects, it must be recognized that there are certain features in the habits and seasonal history of each species which differ to a greater or less extent from those of all other species, even of the same genus; that there are certain features in the characteristics of the various species of trees which differ from those of all other species; and that as a rule it is the technical knowledge of these peculiar features or characteristics of the trees and their enemies which furnishes the clew to successful methods of control.

There are also many peculiar features in the prevailing conditions in different localities, some of them favorable, others unfavorable, for the practical application according to a given method, so that while certain general advice may apply in a broad sense and be available for utilization by the practical man, whether owner, manager, or forester, without further advice, it is often necessary to diagnose a given case before specific expert advice can be given as to the exact cause and the most effective method or policy to be adopted, just as a physician must diagnose a case of illness or injury before prescribing the required treatment for his patient.

Therefore, in a consideration of the problem as to how far the waste of forest resources caused by insects can be prevented and how far the damaged timber can be utilized, we will attempt to give only general statements based on the results of our observations relating to some of the principal kinds of loss discussed in Circulars 125 to 128, inclusive, of this Bureau. In addition, we will consider in this circular the utilization of natural enemies of injurious insects and the utilization of waste caused by insects.

UTILIZATION OF NATURAL ENEMIES AND FACTORS IN THE CONTROL OF INJURIOUS INSECTS.

Were it not for the natural checks and natural factors of control of some of the more destructive insect enemies of forest trees and forest products, artificial control would in many cases be impossible, and the depredations would evidently be far more continuous and complete. These natural factors in the control of the depredating insects consist of parasitic and predatory insects, diseases of insects, birds, adverse climatic conditions, etc. While one or more of these beneficial factors exert a continuous and powerful influence toward the prevention of a much greater waste of forest resources, it has been repeatedly demonstrated that they can not be depended on to prevent widespread devastations or to otherwise work for the best interests of the private or public owner by protecting the best trees and the best tree species. The insects and birds which prey upon the depredating insects also have factors to contend against, consisting of insects, birds, diseases, and climatic conditions. Therefore under normal conditions the tendency is toward the preservation of a balance between the warring factors, but frequently the enemies of the trees get the ascendancy and take on the character of an invasion, which may continue for two or three or even ten years before the balance is again adjusted through the influence of the natural enemies or diminished food supply. Thus a vast amount of timber or of a given forest product may be destroyed before the factors of natural control can prevail.

It is evident that the most effective utilization of the agencies of natural control will be through the alliance with them of the owner of the forest by his efforts toward an artificial reduction of the enemies of the trees rather than by efforts to make the natural enemies of the injurious insects his allies through artificial introduction or dissemination. The former is accomplished by the adoption of methods of combating the invaders which will reduce and weaken their forces below their power of prosecuting aggressive movements and attacks, or, as previously stated, to reduce their numbers to the point where they must occupy a defensive position against their natural enemies and be dependent for their supplies of food and breeding places upon that furnished through avoidable mismanagement of the forests and manufacturing operations. Thus the owner of the forest can contribute greatly toward the preservation of a balance which will be to his material benefit. On the other hand, he may in the future, as in the past, contribute greatly to the multiplication of the depredating insects and to greatly increased losses caused by them through neglect or a disregard of available information on the fundamental principles of insect control in the management of forests and manufacturing enterprises.

BENEFICIAL INSECTS.

The beneficial insects comprise those which are internal or external parasites of the immature or mature stages of the injurious insects, and predators which feed on the young or adults of insects either before or after they make their attack on the trees or products. These two beneficial factors are doubtless far more effective in the long run than any other agencies of natural control. Yet they, in combination with all other factors, can not be relied upon to render continued and efficient control. They can, however, be relied upon to respond to artificial assistance in reducing the numbers of the depredators.

BENEFICIAL DISEASES OF INSECTS.

It is very evident that the parasitic fungi and bacteria which sometimes cause epidemics among injurious insects often exert a powerful influence toward the control of extensive outbreaks or invasions of insect enemies of forests. Indeed, it appears that the greatest service rendered by this class of natural enemies is in the frequent sudden appearance of an epidemic which kills off a destructive species of insects after the latter has increased to such numbers and extended its depredations over such vast areas as to be far beyond the control of man or his insect and bird allies. Numerous examples of this kind of natural control are found in the sudden ending of widespread depredations by various species of caterpillars and sawfly larvæ which defoliate deciduous and coniferous trees. As a rule, however, the beneficial effects of the diseases of insects prevail only after the injurious insects have increased to excessive numbers. Therefore this factor of insect control can not be depended upon to hold the insects in check or prevent outbreaks. The fact, however, that it operates on a class of insect enemies of the forest (defoliators) which at present can not be controlled by any known artificial methods renders the services of the diseases all the more valuable.

It is believed that with further knowledge of nature's method of propagating, perpetuating, and disseminating the diseases which cause epidemics among insects they may be utilized more or less successfully through artificial propagation and dissemination to prevent threatened invasions of defoliating insects.

BENEFICIAL BIRDS.

It is very evident that certain kinds of birds, such as woodpeckers, render valuable service toward the natural control of destructive bark and wood boring insects. They appear to render the greatest service, however, where but few trees are being killed or injured, because their concentrated work on such trees may contribute toward the prevention of an abnormal increase of the insects. They also

render some service as allies of the other beneficial factors which assist in artificial control. It is evident, however, that where many hundreds or thousands of trees are being killed the comparatively limited number of birds in any forest under the most favorable conditions could have little or no beneficial effect. Therefore, while the birds should be classed among the valuable friends of the forest, and should be protected, it is plain that they can not, even with the utmost protection, be relied upon to protect the forest against destructive ravages of insects.

We must remember, in this connection, that there are complicated interrelations between birds, injurious insects, and beneficial insects which do not necessarily operate to the benefit of the forest. In fact, it may sometimes be quite the reverse. Therefore, in order to derive the greatest benefit from the conflict between the birds, the insect enemies of the trees, and the insect friends of the trees, we must utilize our knowledge of the factors which are contributing toward the preservation of a balance, so that whenever the enemies of the forest threaten to get beyond natural control we may enter the field through artificial means and endeavor to force them back to their normal defensive position.

BENEFICIAL CLIMATIC CONDITIONS.

The benefits to be derived from climatic conditions which are detrimental or destructive to insect enemies of the forest, while sometimes very great, are necessarily unreliable, and thus can not be depended upon to assist in artificial control. In fact, the very condition which may contribute to the destruction of one depredator may favor the multiplication of another.

UTILIZATION OF WASTE CAUSED BY INSECTS.

When we come to consider the vast amount of standing timber in the forests of the country which has been injured or killed by insects, and will go to waste if it is not utilized within a limited period, we realize that there are great possibilities in its utilization as a means of preventing the reduction of future supplies of living healthy timber. It is all the more important that the insect-infested timber should be utilized, because in so doing we can contribute more perhaps than in any other way to the reduction of the insects to or below their normal numbers, and thus provide against serious injury in the future, as well as to the maintenance of control.

Approved:

JAMES WILSON,

Secretary of Agriculture.

WASHINGTON, D. C., *October 7, 1910.*









