THE WESTERN YELLOW PINE BEETLE.

A seminar thesis
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I. INTRODUCTION.

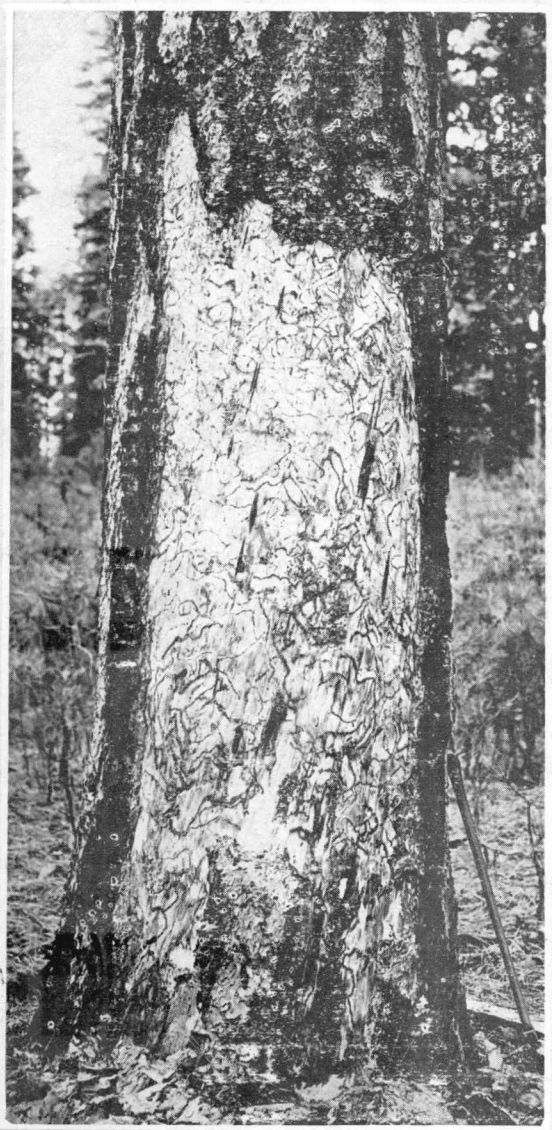
The western yellow pine beetle (Dendroctonus brevicomas Lec.) is one of the most destructive agents in the yellow pine region. Every year it destroys enormous quantities of timber throughout the ponderosa pine region. This loss is natural if the infestation is normal or endemic, and little can be done to eleminate it as a balancing element of nature. But when an epidemic occurs, the timber owner must introduce artificial control in order to keep his losses normal.

Under endemic conditions, the beetle will probably kill less than one percent of the stand in any one year. But frequently, in localities particularly favorable to the beetle, they build up the broods until as high as ten percent of the stand may be killed in one year. The seriousness of such a situation can be seen by observing that from 1930 to 1935, 4,500,000,000 board feet of pine was killed by the beetle in region six, an amount almost equal to the total cut during that period.

This beetle confines its attacks to ponderosa pine and also Coulter pine in California, and to the main trunk of the attacked trees. Rarely does it go into tops less than six inches in diameter or into the limbs.

THE WESTERN PINE BEETLE
(Dendroctonus brevicomis Lec)

(Below)
Bark removed from infested ponderosa pine showing the typical winding egg galleries. Note the streaks of blue stain.



(Above) Inner surface of bark showing egg galleries packed with boring dust and (insert) adults, pupae and larvae, all natural size.

II. LIFE CYCLES.

The beetle has a habit of girdling the trees by feeding on the cambium and for this reason is referred to as a "bark-borer". It is a small, brown to black, cylindrical, rather stout beetle, about the size of the ordinary pencil lead and about 3/8 inches long. It's peculiar feeding habits and method of girdling distinguish it from other bark borers and thus it is easily recognized. Like most of the important forest insects it passes through four stages of developement in the life cycle.

First, a small white egg about the size of a pin point is laid by an adult female in tiny niches along the gallery walls in the cambium, and, are hatched in about 7 days. About the time the eggs hatch, the cambium begins to discolor, wither, and loosen from the tree, and the parent beetles will be found at the end of the egg-galleries where they finally die.

The second stage begins when the eggs hatch into tiny, soft-bodied grubs or larvae. They feed for a short distance through the cambium increasing in size until, when about half way through the bark, they reach maturity and transform to the pupa or resting stage, the third stage.

The beetle is particularly sensitive during the third cycle and it is during this period that the greatest mortality takes ~~mortality takes~~ place. It takes from 6 to 18 days under normal conditions for the beetle to pupate and emerge as a full grown adult or the fourth stage.

III. BROODS AND ATTACKS.

There are two broods a year. One emerging in the spring and early summer months of May, June and July, from the over-wintering infestation. The second brood emerges in the fall months of August, September and October. Trees killed by the first brood are called summer-killed and trees killed by the second brood are called winter-killed. During unusually long seasons with early warm springs and late balmy falls there may occur rather rarely, three broods a year. Under these circumstances, it is very difficult to control an epidemic infestation since from actual counts, it has been found that enough beetles are hatched from a single tree to kill eleven other trees provided all beetles made successful attacks. However, many of the beetles which emerge are killed by predators, other natural enemies and by sap flow of trees resisting the attack.

The first evidence of attack is the faded appearance or pale color of the needles, gradually changing to a yellow or sorrel and then to a bright red. The first fading occurs in the terminal needles in the needle clusters and usually from the top of the tree downward. This needle fading is not to be confused with natural shedding where there are so many dead needles as to resemble an attack, as natural shedding occurs from the base of the needle cluster outward.

Closer examination of a fading tree will reveal small circular holes about 1/16 of an inch in diameter usually in the

bark crevices. A small amount of sawdust and quite often pitch tubes can be found on the bark where the beetle has forced an entry. Chopping in to the sapwood will expose the winding egg galleries in the cambium. These egg galleries are filled with sawdust or leavings, and cross and recross to form a network of irregular lines typical of the yellow pine beetle and is it's identifying characteristic.

If the new brood of beetles have pupated and emerged, the bark will be full of small holes resembling bird shot, and in this case, it is useless to attempt artificial control on that tree.

After emergence, the new beetles enter a period of flight, after which they concentrate an attack upon trees to which they are attracted, usually starting from the top, working downward until the resistance of the tree is overcome and the girdling is complete. Girdling may require from a few days to a week or more, a successful attack requiring about 24 parent adults to the square foot of bark.

The new beetles emerging from the "summer-trees", attack and kill new trees during August, September and October. After the attack, the eggs are laid, hatch and develope until stopped by the advent of winter. The insects pass the winter in all stages of developement from egg to adult, and remain dormant until warm weather in the spring brings a renewal of activity.

IV. TREE MORTALITY DISTRIBUTION.

In the selection of trees under endemic conditions, the beetle shows preference for the slower growing, injured and unhealthy trees of low vitality, and confines it's attack to single trees and small groups of 2 to 5 on the poorer sites, but during an epidemic condition the beetle shows little preference and may attack the youngest and most vigorous appearing trees and successfully kill them. Under such conditions, the tree groups increase until they may reach as many as 150 in a single group, without regard to site conditions. Stands on the poorer sites are often killed until the remaining trees are unprofitable to log under any circumstances, and even the better sites may be seriously damaged before an epidemic is controlled.

V. NATURAL CONTROL.

There is little doubt but that an epidemic would eventually be controlled by natural means because of the fact that as the number of beetles increase it's natural enemies wax fat and also tend to increase, and the pine beetle has many parasitic and predaceous enemies, mites, bacterial and fungoid diseases and bird enemies.

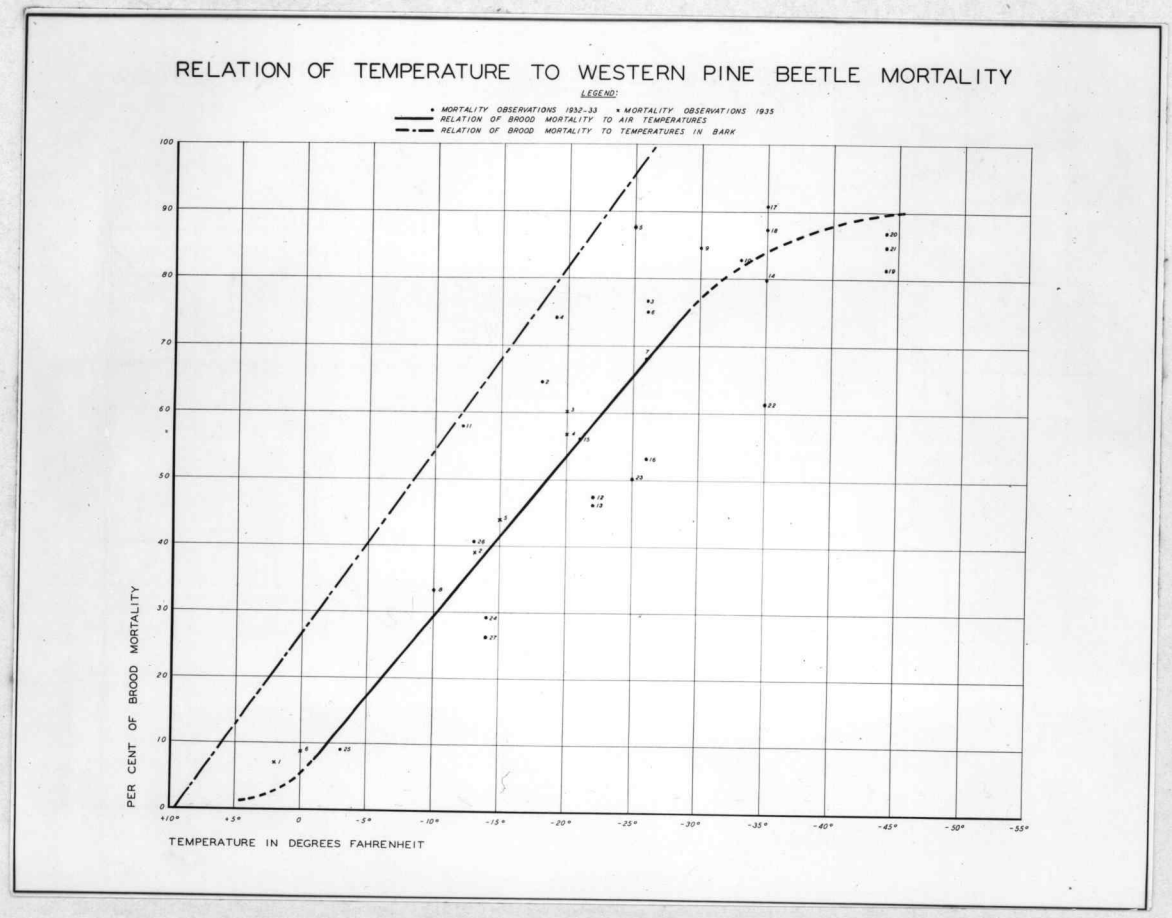
There are two important predators that devour great numbers of beetles before they bore into the bark. One of these, the Clerid (Thanasimus nigriventris) is a grey beetles about three-eights of an inch long. On warm days, it may be seen running actively over the bark of trees that are being attacked by the pine beetles. These predators are attracted to the tree by the attacks of the first beetles, and they (the predators) seem to have the habit of lying in wait for the beetles as they (the beetles) come to the tree. Another common predator is the Ostomid, a bright metallic-green or bluish-green and somewhat flattened beetle, equipped with strong pinchers. The larvae of both the Clerid and Ostomid live under the bark (of the pine) and feed on the immature stages of the pine beetle.

Another important enemy of the pine beetle is the woodpecker. There are several species of woodpeckers that feed on the beetles, and they can be seen and heard pecking away at the (point) grubs or larvae in the bark. They are especially active during the winter when other sources of food are restricted. Some times the woodpeckers nearly strip the bark from an infested tree in their search for "bugs".

There is another factor or element that has been an effective control for epidemic conditions but is unpredictable and has occurred only sporadically:- freezing. The first effective freezes that offered an opportunity to the investigators for determining beetle mortality occurred in December, 1932 and February, 1933.

The Bureau of Entomology, in cooperation with the Forest Service, made exhaustive studies of freeze mortality by obtaining bark samples from throughout the pine region of Oregon and Washington, and cutting up these bark samples and counting the live and dead larvae. They found the mortality to be as high as 91 percent, and on the average a heavy mortality, probably due mainly to the fact that the freezing temperatures occurred suddenly and lasted for several days. Previous and subsequent investigations of freeze mortality have furnished data for the construction of the accompanying mortality chart on the following page.

It will be seen from examination of the chart that there is a definite correlation between freezing temperatures and mortality, and that it would be possible for a severe freeze to reduce an epidemic to an endemic stage. Such a thing happened in the winter of 1932 but because of the ideal conditions for beetle propogation, the infestation was still epidemic in many of the areas after the freezes.


RELATION OF TEMPERATURE TO WESTERN PINE BEETLE MORTALITY
LEGEND:
• MORTALITY OBSERVATIONS 1932-33 × MORTALITY OBSERVATIONS 1935
RELATION OF BROOD MORTALITY TO AIR TEMPERATURES
RELATION OF BROOD MORTALITY TO TEMPERATURES IN BARK
PER CENT OF BROOD MORTALITY
100
90
80
70
60
50
40
30
20
10
0
+10°
+5°
0
-5°
-10°
-15°
-20°
-25°
-30°
-35°
-40°
-45°
-50°
-55°
TEMPERATURE IN DEGREES FAHRENHEIT

VI. ARTIFICIAL CONTROL.

During an epidemic, it is vital that artificial control be developed in order to reduce the tremendous losses. Artificial control is not a new art, and there has been developed several rather effective methods, the best being the burning method which consists of felling the tree, peeling off and burning the bark. This method of control is best carried on in the fall, winter and spring when there is least danger of fire spreading, and the beetles are dormant.

The control work is divided into two elements - spotting and treating. Spotting, as finding infested trees is called, is carried on by a crew of tree men: a compassman, who runs a compass line, paces distances and maps the infested trees on usually an 8-inch to the mile map; two spotters, who take a five chain strip on each side of the compassman. Their job is to find all the infested trees, blaze the tree on three sides and number it. Then they call the numbers to the compassman, who maps the location of the tree. Ordinarily a spotting crew will spot one-half section a day or four miles of line.

The treating crews follow the spotting crew into the infested area. They are given tools and a map of the section furnished by the compassman, and it is their job to fall the tree, peel and burn the bark. The treating crew is usually composed of only two men although more can be used. Care should be exercosed in falling an burning so that other trees are not injured.

When treating a group of infested trees, the work is greatly expedited by piling the trees. This piling usually causes the logs, and especially the smaller ones, to be completely consumed. Trees that are peeled and scourched may be used for lumber if removed from the forest within two years, and furthermore, they do not deteriorate as rapidly as those that are left standing, so that, while control work appears to be a very destructive operation, nature's own processes are even more so.

Another method of control is the sun curing method, wherein the tree is felled, the bark peeled off and laid on the open ground either side up so as to be exposed to the direct rays of the sun for at least two hours a day. This exposure will raise the temperature in the bark enough to be lethal. This makes an ideal summer treating method but in practical application, such factors as slope, exposure, denseness of forest cover, brush, cloudy weather and others make the effectiveness of this method uncertain and for that reason it is no longer used on any extensive scale.

Trap trees as a means of localizing infestation and simplifying control have often been advocated but after extensive tests on the San Joaquin project in California, the conclusion was reached that the trap trees fail to trap infestation is sufficient quantity to protect the surrounding forest. Therefore, their use is not advocated unless the timber can be utilized.

Probably the most effective method of control is through regulatory cutting. It's application and effectiveness covers a long period of time, but the basic principles are fundamentally sound. It is a well known fact that the beetles attack the weaker, less vigorous individuals, and, to some extent, those more advanced in age. The problem therefore, is to recognize the combination of characters which indicate susceptibility and that is what F. P. Keen of the Bureau of Entomology at Portland, Oregon has done.

VII. TREE SUSCEPTIBILITY

In Keen's studies of susceptibility, he has taken Dunning's tree classification which recognizes 7 tree classes and regrouped the trees according to age and vigor. Keen has four age groups. Young--usually less than 75 years of age; rarely over 20 inches D.B.H.; dark grayish-brown to black bark, deeply furrowed, with narrow ridges between the fissures; tops usually pointed, but with nodes indistinct, branches mostly upturned and in whorls for upper half of crown. Immature--approximately 75 to 150 years of age; rarely over 30 inches D.B.H.; dark reddish-brown bark, with narrow smooth plates between the fissures; tops usually pointed, with distinct nodes, and branches mostly upturned and in whorls for upper half of crown. Mature--approximately 150 to 300 years of age; rarely over 40 inches D.B.H.; light reddish brown bark with moderately large plates between the fissures; tops pyramidal or rounded, branches upturned near top, those of middle crown horizontal, lower ones drooping, whorls incomplete. Overmature -- more than 300 years of age; usually of large diameter; light yellow bark, the plates usually very wide, long and smooth; tops usually flat and making no further height growth; branches mostly drooping, gnarled, or crooked.

In each age class Keen has four vigor groups, designated by letters A to D as follows: A -- full, vigorous crowns, with a length of 55 percent or more of the total height, and of average width or wider; foliage usually dense; position of tree isolated or dominant(rarely codominant); diameters large for age. B -- fair to moderately vigorous crowns with average width or narrower, and length less than 55 percent of the total height; either short wide

crowns or long narrow ones, but neither sparse nor ragged; position, usually codominant but sometimes isolated or dominant; diameters above average for age. C -- fair to poor crowns, very narrow and sparse or represented by only a tuft of foliage at the top; foliage usually short and thin; position usually intermediate, sometimes codominant, rarely isolated; diameters below average for age. D -- crowns of very poor vigor; foliage sparse and scattered or only partially developed; position suppressed or intermediate; diameters decidedly subnormal, considering age.

By combining the four age sub-groups with the four sub-groups of crown vigor a total of 16 classes was obtained which could be analyzed for relative susceptibility.

According to definition, the comparison between the expanded classification and Dunning's classification is as follows:

Classes defined by Dunning	Bark-beetle susceptibility class
1	1A, 2A
2	1B, 2B
3	3A
4	3B, 3C
5	4A, 4B, 4C
6	1C, 2C, 1D, 2D
7	3D, 4D

Or, in reverse order:

Bark-beetle susceptibility classes		Dunning's classes
Age group	Vigor group	
1	A, B, C, D	1, 2, 6, 6
2	A, B, C, D	1, 2, 6, 6
3	A, B, C, D	3, 4, 4, 7
4	A, B, C, D	5, 5, 5, 7

VIII. RESULTS OF CONTROL.

An appraisal of the results of past control work and the conditions under which future work is recommended, are described in the following quotation from an article in the November 1931, issue of the Journal of Forestry, entitled "Control work against bark beetles in western forests and an appraisal of its results".

"Admittedly the success of all these projects for western pine beetle control has not been spectacular or outstanding. In many cases the work has shown tangible results, but often these results were not substantial enough to show a profit. Some projects were apparently failures. The data to prove positively either success or failure of certain projects are often inadequate. Indirect benefits of control work, such as the reduction of fire hazard, are usually too intangible to be appraised. With the data at hand any broad conclusions, therefore, must be based upon convictions of entomologists and owners who have had long experience in this work, rather than upon overwhelming weight of evidence. The predilection of the western pine beetle for slow-growing trees and its apparently quick response to climatic influences must also be taken into consideration. With these limitations in mind, it is believed that the following conclusions are considered reasonable by all who have followed and closely analyzed these projects.

1. One season of thorough control work results in a reduction of western pine beetle losses on the treated areas as compared with similar untreated areas.

2. The benefits have been greatest when the natural tendency of the infestation is upward.

3. Under a declining infestation, there was only a small difference in favor of the treated over the untreated areas.

4. The benefits from control work have been temporary, lasting only one or two seasons, and a return to conditions similar to those on untreated areas can be expected unless work is continued on the same area year after year.

"In the face of these results, under what conditions is direct control work to be recommended? Considering both economic and entomological factors, control of the western pine beetle is believed practicable under the following conditions:

1. In parks and on recreational areas with high values, where trees are objectionable and should be removed for aesthetic considerations or for those of forest sanitation. Under these conditions, control work need not necessarily pay its way on the basis of stumpage values saved from further beetle attack.

2. On small, well-isolated areas, where the timber is of high value and where the entire infestation can be treated in one season.

3. On large areas, preferably with partial isolation, where the entire infested area can be treated and where it is to be logged within three or four years.

4. In commercial stands, whether isolated or not, where control work can be supplemented by logging and salvaged at a low cost or a small profit. Such work may be combined with selective logging to remove susceptible trees and produce better growth conditions, in order to give permanent protection for long periods."

IX. INVESTIGATIVE AND CONTROL AGENCIES.

The Bureau of Entomology is the foremost investigative agency of the western pine beetle. The areas of investigation embrace the same regions as do the national forests. Particular attention is here given to the Bureau of Entomology in region six.

This bureau was established in Portland, Oregon in 1928 with F. P. Keen in charge. He has carried on extensive investigations into the mortality of trees from insect attack. He has established an extensive system of sample sections throughout the region and particularly in southern Oregon where the damage has been heaviest. Each year these plots are spotted and the damage recorded by the brood, the size and height of the tree and the class of tree.

From the compilation of this data collected, Keen has been able to plot a curve showing the relation of insect attack to climatic conditions. He has also been able to plot climatic cycles and is attempting to determine a definite correlation between climate and attack and derive some method of predicting future epidemics.

As for control, the Bureau of Entomology acts only in an advisory capacity. The actual control is carried on by the Forest Service, Park Service and private agencies. The Forest Service confines control to national forest but does sometimes treat small areas privately owned within the national forest in cooperation with some other control agencies. The spirit of cooperation has been developed to a high degree and in nearly all cases of control where alien lands adjoin, cooperation is mutual to keep insect losses at a minimum.

X. LEGISLATION.

The past lack of cooperation in control has brought about legislation that allows a protective organization to practice control measures on infested contiguous areas and force the owner to pay for the control. The provisions of this law are stated in full as it appears in Chapter III of the Oregon Forest Laws, 1931.

"Public nuisance.

Pine beetles and other insect pests and infestations harmful, detrimental and injurious to timber and forest growths and to timber infested thereby are declared to be a public nuisance.

Landowner - Eradication of pests.

Every owner of timber or timberlands shall control, destroy and eradicate such insect pests, or provide for the same to be done on lands owned by him or under his control, but in case of his failure or neglect so to do, such work may be performed as provided for in this act.

Infested area - Notice to state forester - investigation - notice to abate nuisance.

When any owner, or owners of timber or timbered lands shall find the same infested with pine beetles or other insect pests, or shall find timberlands adjacent thereto so infested, he or they shall immediately notify the state forester thereof, whereupon it shall be the duty of the state forester at once to investigate such condition and if in his opinion the infestation is of such a character as to be injurious to forest growths and a menace to timber or timbered lands, the state forester, with the approval of the state board of forestry, shall declare a district or zone of infestation, and declare and fix boundaries thereof so as to definitely describe and identify such district. Thereafter and upon written application of the owners of 60 percent or more of the timber or timbered lands within said infestation (infested) district that the provisions of this act be enforced and that said nuisance be abated and that the said insect pests be eradicated and destroyed, the state forester shall at once notify all owners of timber and timberlands within the said district to proceed under the provisions of this act without delay to destroy and eradicate the said pests as provided herein. The said notice may be made by personal service, or by mail, addressed to the last known place of address of such owner, sealed, plainly addressed, with the requisite amount of postage stamps thereon, and deposited in the United States post office. Such service may be

made on an agent of the owner, or upon any person of legal age in possession of or residing upon said lands.

Owner failing to abate nuisance - Duty of state forester.

If the owner or owners referred to in the last preceding section fail, refuse or neglect to comply with the requirements of said notice for a period of 50 days after the date thereof, it shall be the duty of the state forester, or the person or persons authorized and directed by him, to go upon said lands, using such assistance and help as he may deem necessary, and to cause such insect pests to be eradicated and destroyed in such a manner as shall be approved by the state board of forestry.

Expense of eradicationby state - Entry on lien docket - Enforcement of lien.

Upon the completion of said work so directed and authorized, the state forester shall make and file with the county clerk of the county wherein the said infestation(infested) district or zone is situated, a verified statement of the expenses necessarily incurred in performing the work of eradicating said pests. Upon the filing of said statement the county clerk shall cause the same to be entered upon a lien docket prepared and kept for that purpose. Said expense account when so filed and docketed shall constitute a first lien upon the timberlands upon which such work was performed, second only to the lien for taxes. If said charges and expenses shall not be paid and fully discharged within ninety days from the docketing thereof, it shall be the duty of the district attorney of said county to bring suit or action in the name of the state board of forestry for the foreclosure of the said lien, and the lands and timber included in said lien shall be sold in the manner provided by law under execution, and the moneys arising therefrom shall be applied in payment of the costs and disbursements of said suit or action and in the payment and discharge of said lien. All moneys so recovered shall be paid over to and become a part of the funds of the state board of forestry and applied in reimbursing said board for the expenses incurred in eradicating said pests.

Landowner-Good faith attempt to eradicate pests - Effect

Every owner and all owners who, upon receiving said notice as provided in this act, shall proceed and continue in good faith to eradicate and destroy said pests shall be exempt from the provisions hereof as to the lands upon which he or they are so proceeding.

Zone of infection - Dissolution

Whenever the state board of forestry shall determine that control work within the designated zone or district of infestation is no longer necessary, said board by resolution may dissolve said district or zone, and whenever the owners of 60 per cent or more of the lands within said district or zone of infestation shall petition said state board of forestry to dissolve said district or zone for the reason that control work is no longer necessary or feasible, then the said board shall by resolution dissolve the same.

Members of cooperative - Exemption from act.

Every owner in any such zone or district who is a member of a cooperative association of timberlands now existing, or which may hereafter be formed and which actively engages in the destruction, control and eradication of the said insect pests and pine beetles, using methods approved by the state board of forestry, shall be exempt from the provisions of this act.

'Timber lands' defined.

For the purposes of this act any land shall be considered timber land which has enough timber, standing or down, to constitute, in the judgment of the state board of forestry, an insect or pine beetle infestation breeding ground of a nature to constitute a menace, injurious and dangerous to timber or forest growth in the district or zone under consideration.

'Owner' defined.

The work 'owner' as used in this act shall include individuals, partnerships, corporations and associations."

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