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Department of Entomology

The Western Pine Bark-Beetle

A SERIOUS PEST OF WESTERN YELLOW PINE IN OREGON

by

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CORVALLIS, OREGON

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CONTENTS

ILLUSTRATIONS

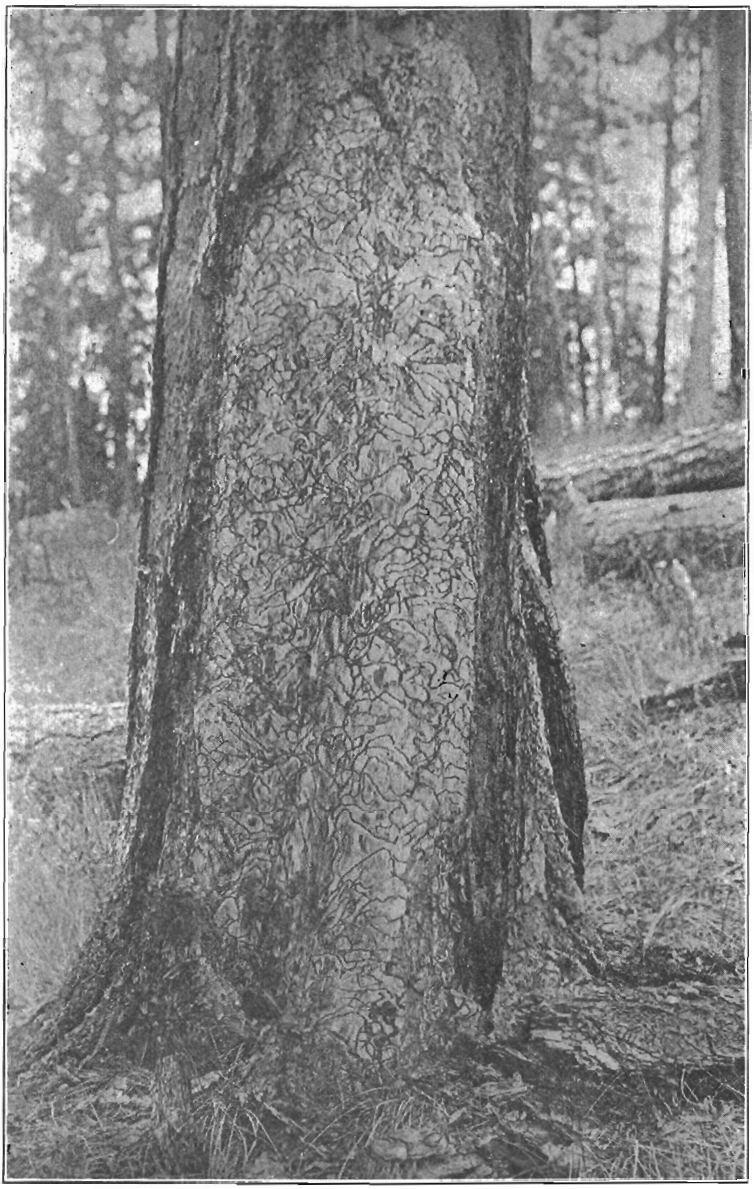

PLATE I.

Western yellow pine killed by the Western pine bark-beetle (Dendroctonus brevicomis), the winding galleries of the beetles showing on the trunk. (After Swaine.)

TIMBER OWNERS IN OREGON are annually losing thousands of dollars through the depredations of timber-killing beetles. The most serious losses at the present time are in Jackson, Klamath, and Lake counties, where the loss due to the work of the Western pine bark-beetle during the past season amounted to some $200,000.

This bulletin is offered as a brief summary of our present knowledge of the biology and methods for the control of this pest.

It is hoped that cheaper and better methods of handling the beetle situation may result from investigations which have been started and which it is hoped can be carried on to a successful conclusion in the forests of Klamath county.

The Western Pine Bark-Beetle

(*Dendroctonus brevicomis* Lec.)

Oregon's greatest natural resource at the present time is its forests, and the State may well be proud of its magnificent stands of virgin timber, excelled by none and equalled by only one other state. These wonderful forests make Oregon the mecca of thousands of tourists, who love the mountains and forests; insure to our cities an adequate supply of pure mountain water; maintain an even flow of our streams for water power; protect our fishing industry; furnish cover for game; supply our own timber needs; and produce the raw material for extensive manufacturing concerns. Over 40 percent of the State's population gain their livelihood directly or indirectly from the forests.

Approximately one-fifth of the standing timber of the United States is found within the borders of Oregon. This vast forest is composed principally of two species of trees, Douglas fir (*Pseudotsugae taxifolia*), and Western yellow pine* (*Pinus ponderosa*). The fir stands contain almost four times as much timber as do the pine stands, but the latter cover a far greater area, occurring on some 14,000,000 acres, or practically one-quarter of the total area of the State and almost one-half the timbered area. The distribution of Western yellow pine in Oregon is shown by the shaded areas in Plate II.

TABLE 1. OWNERSHIP AND STAND OF YELLOW PINE IN THE PRINCIPAL COUNTIES OF OREGON

	Privately owned yellow pine timberland		Government yellow pine timberland		Total	
County	Acres	Feet b.m.	Acres	Feet b.m.	Acres	Feet b.m.
Klamath	836,750	7,393,000,000	994,000	10,725,600,000	1,830,750	18,118,600,000
Crook	535,346	6,847,900,000	638,115	6,415,000,000	1,173,461	13,262,900,000
Lake	301,539	3,340,000,000	569,232	5,500,000,000	870,771	8,840,000,000
Grant	301,820	2,853,000,000	884,200	5,315,000,000	1,186,020	8,168,000,000
Jackson	592,751	5,431,000,000	31,840	223,000,000	624,591	5,654,000,000
Wallowa	171,330	1,808,500,000	517,156	1,525,000,000	688,486	3,333,500,000
Baker	213,168	1,536,000,000	306,064	1,345,000,000	519,232	2,881,000,000
Wheeler	198,875	1,586,000,000	101,690	1,101,000,000	300,565	2,687,000,000
Harney	36,960	339,000,000	315,335	2,285,000,000	352,295	2,624,000,000
Union	235,640	1,561,000,000	119,800	395,000,000	355,440	1,956,000,000
Other counties	923,847	2,117,000,000	1,076,048	1,660,100,000	2,114,895	3,837,100,000
Total	4,448,026	34,812,400,000	5,543,480	36,489,700,000	10,006,506	71,362,100,000

Figures for 1915 from U. S. Dept. of Agriculture Bul. 418. T. T. Munger.

Most of Oregon's 70,000,000,000 feet of Western yellow pine occurs in ten counties, each having over 1,500,000,000 feet board measure and 300,000 acres of commercial yellow pine timber-land. Table I gives the stand, acreage and ownership of the yellow pine in the ten counties.

Oregon's cut of Western yellow pine in 1915 was 189,203,000 feet board measure. This timber was handled by 134 mills ** of all types, ranging from small, portable mills, running at irregular intervals and having a capacity of only 6,000 feet board measure a day, up to the

* Many common or trade names are applied to Western yellow pine such as "Western pine," "Western soft pine," "Oregon white pine," "Yellow pine," or simply "pine."

** Most of the mills cut other species in addition to the pine.

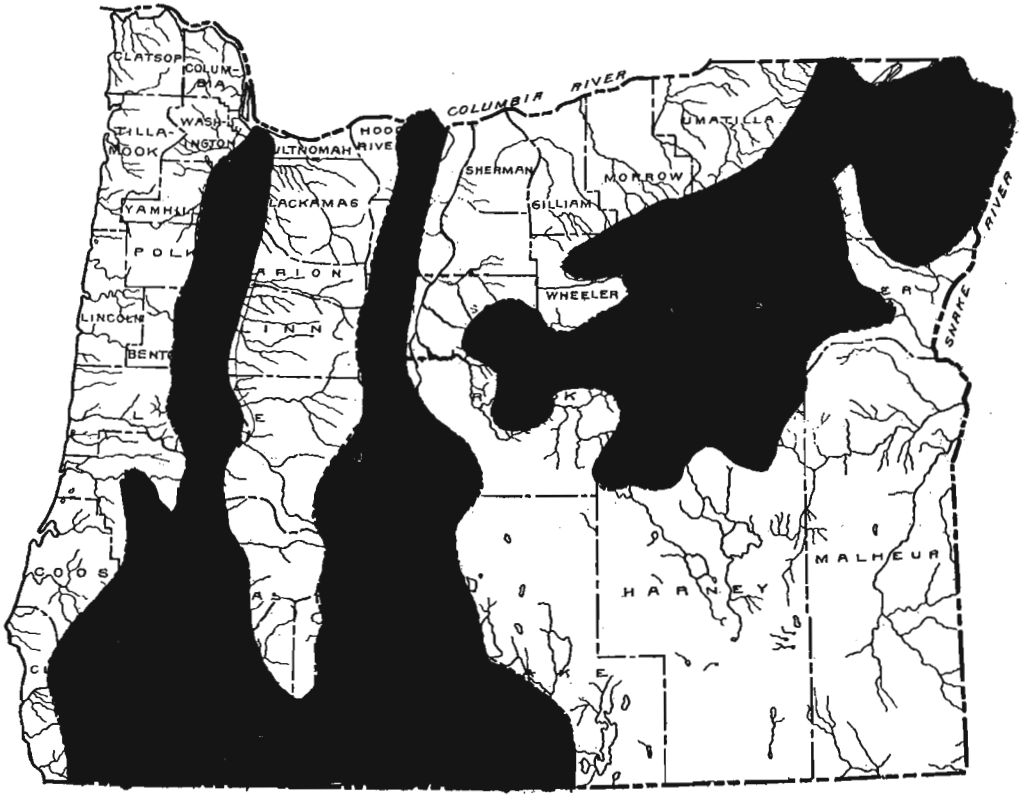

PLATE II.
Map showing the distribution of yellow pine in Oregon.

large modern mills operating band saws and capable of turning out 300,000 board feet in a day of two shifts.

From these considerations it is clear that the protection of the forests is of vital importance, not alone to the timber owners but also to the State, whose welfare, income, and prosperity depend to such a great extent upon this resource. These forests if once destroyed, can be replaced only by careful guarding through many generations, since the average age of the trees being cut from the better stands of yellow pine in Oregon is in excess of 200 years and it takes about 90 years to produce a tree twelve inches in diameter.

Forest Protection. When we speak of forest protection in this region, it is usually understood that the prevention and suppression of forest fires is implied. This is, of course, one of the main problems in the administration of coniferous forests, and it is the one to which the greatest attention has been given in organizing along protective lines.

The problem of forest protection does not, however, mean safeguarding against fire alone. There are other sources of injury that, under certain conditions, may cause widespread damage. The most important of these problems is the suppression and holding in check of insects that are injurious to forest trees. It is very essential that the forester have a proper conception of the subject of forest entomology in its technical and economic phases, and appreciate thoroughly the activities of various species of insects that he may have to combat, in order to bring his crop to a successful maturity.

The principal insects with which the forester is concerned may be grouped arbitrarily into several classes, depending upon the character of their work.

The first and most important class comprises those insects that, in some stage, work between the bark and wood of the main trunk or branches, and through the destruction of the cambial tissues, cause the death of the living trees. In this class are the true bark-beetles. of the family *Scolytidae*; also numerous species of several other families of beetles, whose larvae are popularly known as round-headed and flat-headed borers. Regarding the true bark-beetles, those belonging to the genus *Dendroctonus* are the most pernicious. The beeltes of this genus depredate exclusively on conifers, and are found wherever such trees grow. In addition to those of primary importance, there are numerous species that have essentially the same habits, excepting that their work is confined to dead or dying trees that have been injured by other causes.

After the trees have been killed by any cause whatever, whether it be fire, primary insects, fungi, or after they have been cut in the ordinary course of logging operations, they are subject to the work of another class of insects which may reduce their value for lumber. These secondary insects are mainly beetles and their larvae that mine through the wood and bark of the dead tree.

Our most serious present insect problem involves the yellow pine stands of Southern Oregon, where the timber has, in many regions, suffered heavily from the work of several species of bark-beetles of the genus *Dendroctonus*.

PLATE III.
Inner surface of yellow pine bark, showing galleries of Dendroctonus brevicomis

The Western pine bark-beetle (*Dendroctonus brevicomis*) is present throughout the yellow-pine regions of Oregon, often attacking the very finest trees in a stand. Normally its action is slow and local, requiring several years to kill a tree, but operating continuously over large areas this beetle probably is the cause of more dead yellow pine than any other single factor. When under certain conditions the beetles multiply rapidly the infestation becomes an epidemic and the timber is killed with startling rapidity over large areas, causing an annual loss in some sections far in excess of the fire loss.

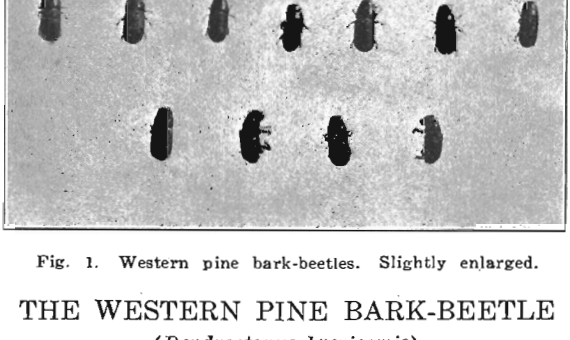

Fig. 1. Western pine bark-beetles. Slightly enlarged.

THE WESTERN PINE BARK-BEETLE

(*Dendroctonus brevicomis*)

The adult beetle is a rather stout, brownish or black beetle, from 3 to 5 mm. (2/16 to 3/16 inch) in length, with a broad head grooved in front (Plate IV, A), pronotum narrowed toward the head and coarsely punctured. The elytra or wing covers have fine, elevated lines. The beetle is clothed above with very short, almost microscopic hairs.

During the larval or grub stage is the time in the development when most of the damage is done. The larva (Plate IV, B) or worm emerges from the egg as a tiny, wrinkled, white, legless grub with a dark head and strong jaws. As soon as hatched it starts feeding on the bark and forming its gallery.

The pupa (Plate IV, C) is the quiescent stage when the insect is changing from the larval or grub stage to the mature beetle. During this transformation the insect remains quiet and does no damage.

SEASONAL HISTORY

The winter is passed as adults and as larvae in all stages of development. A few of the adults will be found in the mines between the bark and the wood but the majority will be found hibernating in the outer part of the inner bark, and the larvae will also be found in the outer layers of the inner bark in their winding galleries.

In the early spring (April or May depending on climatic conditions) the over-wintered adults become active and begin extending their gal-

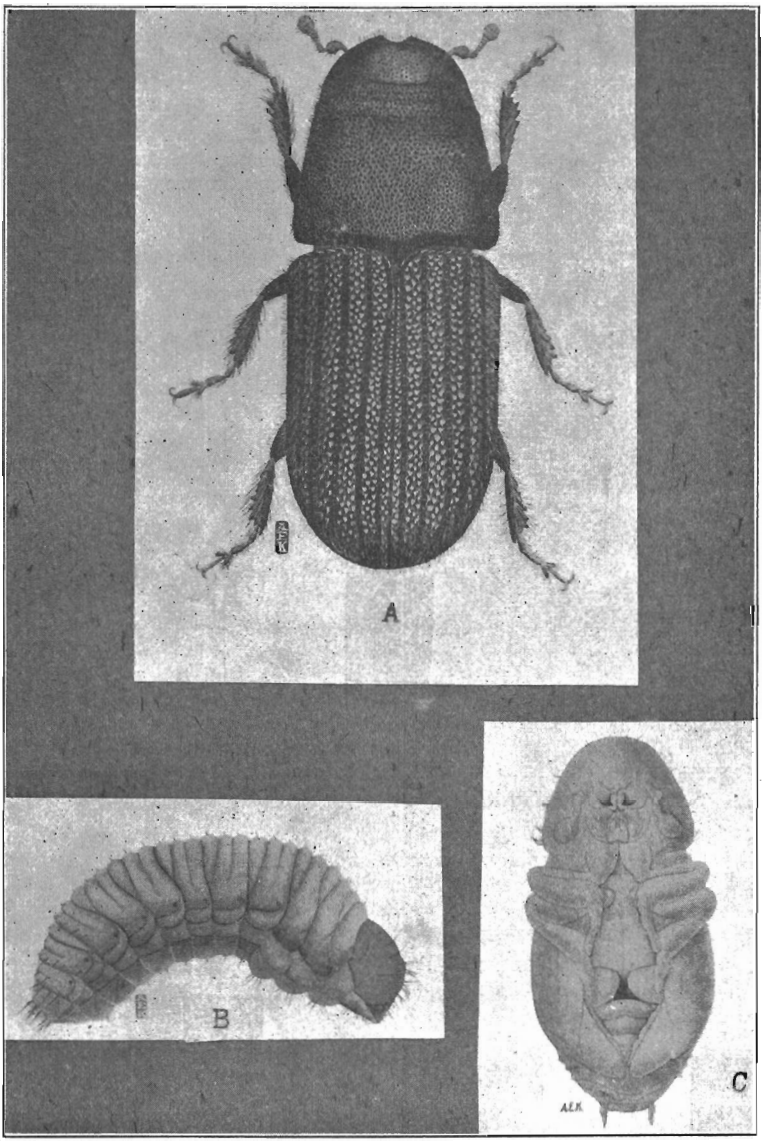

PLATE IV.

A. Adult Western pine bark-beetle (D. brevicomis Lec.) Greatly enlarged.
B. Dendroctonus larva. Greatly enlarged.
C. Dendroctonus pupa. Greatly enlarged. (After Swaine.)

leries or digging new ones and depositing eggs. From the eggs deposited in April, broods of beetles will emerge in late July and early August.

Those individuals which passed the winter as newly transformed, or young, adults will leave the parent tree in May or June. From this time on there will be almost a constant emergence of adult beetles from the infested trees due to the continual development and transformation of mature larvae. The first of these adults will emerge early in July and the last ones will come out in September. The principal period of attack by the emerging beetles is July and early August. Some of the late-emerging beetles are from the eggs deposited in April and May. There is considerable variation in the time required for the development of the insects from egg to adult. Eggs may be found in the bark soon after the first warm days of spring and from then on until late fall. All stages will be found throughout the year, except the pupae. .These do not seem to be present from October until late May.

From the foregoing remarks it may oe seen that there is almost a constant emergence; this is due to the irregular development of the broods. There is one and a partial second generation a year, however, and though the broods have their stragglers and retarded individuals the main portion of what we can term the first generation emerges in July and August and from the eggs deposited by these, adults will emerge in numbers in May the following year.

Summary of Seasonal History. Over-wintering forms: Parent adults; young adults and larvae of the second brood.

Seasonal History of Over-wintered Forms:

Parent Adults: Eggs deposited in April and May; adults appear late July and August.

Young Adults: Emerge in May or June; attack new host and deposit eggs June-July. Adults which develop from these eggs emerge August and later; egg galleries excavated and eggs laid for the second brood, which winter as larvae.

Over-wintered Larvae: Transform to pupae in April-May and adults emerge during July and August.

LIFE-HISTORY

The adult beetles dig through the bark of healthy, injured, fallen, or standing timber and excavate winding galleries (Plates I and III) in which the eggs are deposited. The eggs hatch in a week or ten days. The young larvae bore their winding galleries through the inner bark. The length of the larval stage varies considerably. The summer brood spends nine to twelve weeks as larvae. The over-winter larvae are in that grub stage for over six months, being inactive during the cold, winter weather. The pupal stage covers a period of three to four weeks.

Distribution. The Western pine bark-beetle is found wherever yellow pine (*Pinus ponderosa*) grows, in British Columbia, Washington, Oregon, California, Idaho, and in parts of Montana, Wyoming, and Nevada.

In Oregon it is common in the scattered yellow pine of the Willamette Valley, abundant in Josephine and Jackson counties, and a serious pest in Klamath and western Lake counties and on the east slope of the Cascade Mountains. It exists in numbers around Hood River and in the Blue Mountain region, including most of the northeastern quarter of the State, and may become serious in that section at any time, though up to the present, a near relative, the Mountain pine bark-beetle (*Dendroctonus monticolae*) has held first place in the order of destructive pests in that section.

Hosts. The Western pine bark-beetle attacks Western yellow pine *Pinus ponderosae* and sugar pine (*Pinus lambertiana*).* The latter tree occurs only in small quantities in Oregon and since the beetle has shown a decided preference for the yellow pine, the loss in sugar pine is negligible.

HABITS

Upon emerging the beetle may re-attack its parent tree, but usually migrates to a suitable, nearby host. Selecting a crevice in the bark, it bores its way to the cambium where it excavates a long, winding egg gallery. The beetles work in pairs, the female doing most of the digging while the male assists in keeping the gallery free from borings, frass, and pitch. As these waste materials are forced out of the gallery they accumulate about the entrance, forming what is known as pitch tubes, which are irregular masses of pitch mixed with the frass and borings. These tubes on the bark usually give the forester the first warning that the tree is attacked. In the egg gallery the female cuts tiny pockets in the walls at intervals of a half-inch or more; these are known as the egg niches and in each is deposited a single, white, oval egg. From this egg a small, wrinkled grub hatches a week or ten days later. This grub or larva excavates its own gallery or larval mine, feeding on the bark. The larval mine is mainly in the inner bark, though it may run in the cambium for a short distance from time to time. When nearly full-grown the larva works its way into the inner portions of the outer bark where it enlarges the end of its gallery into an oval chamber, known as the pupal cell. In this cell the larva rests and soon a transformation takes place. It loses its grub-like appearance and begins to take on the characters of the adult beetle. This is the quiescent or pupal stage when the legs, wing pads, antennae, and other characters of the adult are plainly seen. The pupa is white in color at first, but after a time will begin to change color, becoming yellow, the wing pads develop into wings and wing covers, the color deepens, and soon there is the newly transformed adult beetle, fully formed. Its color is now a pale brown but darkens from day to day, and the young adult begins boring its way through the outer corky bark, emerging through a tiny round (Fig. 2) exit hole to join others of its kind and attack another tree.

* From extensive observations it would seem that the few records of D. brevicomis in sugar pine are purely accidental.

IMPORTANT ASPECTS OF THE LIFE-HISTORY AND HABITS

It is important to remember the following facts: (1) The larvae of this insect pass most of their life in the middle layers of the bark. (2) The insects emerge through small, shot-like holes around which there will be no resin tubes. The presence of large numbers of these exit holes in trees with yellowish or reddish foliage indicates that the

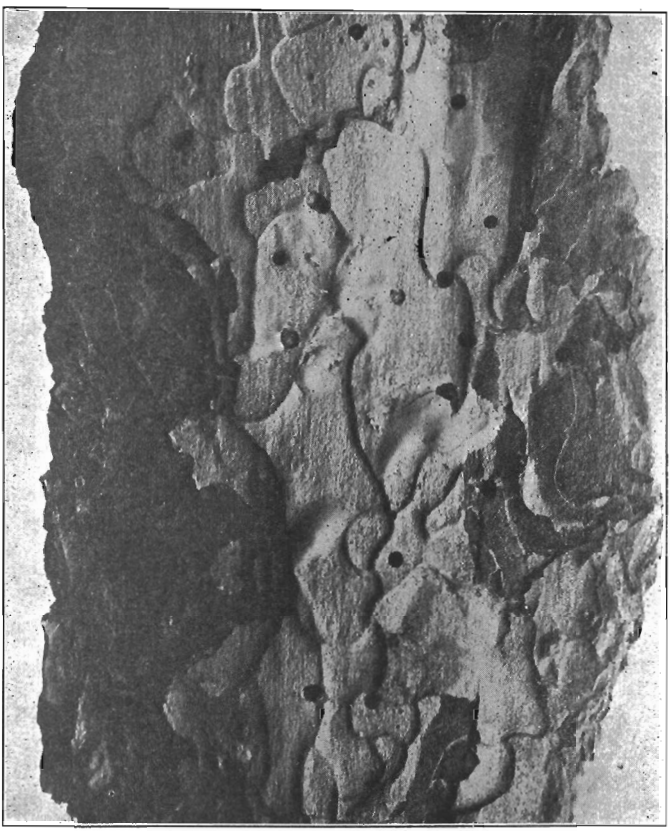

Fig. 2. Section of yellow pine bark showing emergence holes of Dendroctonus brevicomis. Natural size.

broods have matured and left the tree; no time or money should be wasted on these "beetle-abandoned" trees. (3) Careful examination should be made of all timber near beetle-abandoned trees to ascertain if the broods, which recently emerged, have not attacked these trees. (4) A tree may remain green even up to the time that the majority of the beetles have left it. The foliage of infested trees usually begins to fail in late summer, turning yellow in fall and winter and becoming a "red top" the following spring. (5) As a rule the emerging swarms of beetles

attack living trees in the immediate vicinity of the parent tree, but at times these swarms fly considerable distances and attack isolated trees or clumps of trees, thus establishing a new center of infestation from which succeeding broods will work out in all directions.

Effect on the Commercial Value of the Wood. The value of the wood of trees killed by this beetle is sometimes reduced by the bluing of the sapwood, often before the needles begin to turn yellow. The heart wood, especially of the larger trees, does not deteriorate until decay sets in. This decay is indirectly due to the mines of the wood borers, which follow close on the death of the tree. The loss to standing trees killed by *Dendroctonus* beetles is negligible if the trees are removed within one or two years. After that time, boring insects, fungi, and storms inflict some loss from year to year and as would be expected the smaller trees are soon rendered useless but large trees (over 36 inches D. B. H.), will remain merchantable for 15 to 20 years. Trees thrown by the wind or other causes deteriorate much more rapidly than do those standing. Trees cut in the course of direct control, from which the bark is removed, piled over them and burned, leaving a charred trunk on the ground, will be found to remain in a merchantable state even longer than the standing trees. This is due to the fact that the removal of the bark prevents the entrance of practically all the wood-boring beetles, as they require bark on which to deposit their eggs. The charred surface of the wood also acts as a repellent to parasitic fungi and allows but little water to enter, thus delaying decay.

Interrelation of Fire and Insects. The fact that insect-killed timber is a serious fire menace must not be overlooked. Fires that would ordinarily be "ground fires," doing little damage, will often develop into serious "crown fires" when they burn into an area of beetle-killed timber. The masses of pitch and resin on and at the base of the trunks of such trees lend the impetus required to lead the flames into the crowns. Fires will of course destroy broods of beetles, but unrestricted burning should never be used to wipe out even the most serious infestations. Conditions may arise in remote regions where carefully planned burning may be used providing a safe fire barrier exists or can be constructed at small cost. Although this burning method has been advocated* no infestation has yet been noted where it was thought such drastic methods could be used with any degree of safety.

Favorable and Unfavorable Conditions for Beetles. Favorable conditions for the rapid multiplication and spread of these beetles are found in regions containing large areas of mature or over-mature yellow pine timber. This is especially true in regions of severe storms where lightning-struck trees are frequent, or where high winds or heavy snows have broken or thrown trees. Such timber, being weakened, offers less resistance to the entering beetles. It is in such material that strong broods develop and emerge to attack the more healthy trees, which under such circumstances can be overcome by sheer force of numbers.

Low temperature, even though extreme, seems to have no direct effect on the beetles. Indirectly it may be favorable to them by weak-

*S. E. White. Sunset. February, 1920.

ening trees due to what is called "frost check," a cracking and loosening of the bark due to freezing and subsequent rapid thawing.

Drought even when extreme seems to have no ultimate influence on the beetles since it is equally detrimental to both the insects and their hosts. In the end both are in about the same relation to each other—weakened.

The Effect of Commercial Logging Operations. Cutting may be injurious or beneficial to beetles according to the time the trees are felled, the method of handling the logs, the method of disposing of the brush and waste material, and according to whether the operation is continuous, i. e., carried on from year to year or whether it is a temporary operation. As to the time of cutting, summer cutting (June, July, August) in a section where the Western pine beetle is abundant is objectionable due to the fact that the odor of fresh-cut pine attracts large numbers of the beetles, many of which will attack nearby green, living timber. Winter cutting during the period September to April, is to be preferred. If the timber is infested it should be converted into lumber and the slabs destroyed before the time of emergence of the beetles or by the first of May. If the operation of converting the logs into lumber entails their transit by, or storage in water, the foregoing statements of the time limits on cutting or converting do not apply provided the logs are put into the water within a reasonable time after cutting, and are allowed to remain there until sawed. The water will destroy a large percentage of the brood.

The Disposal of Slash, Culls, etc. It is in the disposal of the refuse that operators have the best chance to bring about a material reduction in the number of beetles in any given locality. By handling the slash in accordance with the life-history of the beetles, vast numbers of the pest will be destroyed at practically no extra expense. The details of brush burning are discussed under the heading, Control.

CONTROL

The object of the timber owner is to bring his crop to maturity and successfully harvest and market it. Since forests from their very nature require large investments for long periods the matter of insurance is of paramount importance. Protection is then vital and the question of fire prevention and control has received much attention; but, as pointed out above, while the question of protection of timber from the ravages of insects is of equal importance, up to this time it has not received the attention it merits.

The control of insect depredations is far different from that of fire: the latter must be controlled at once, while the former may be attended to during slack seasons and in a more leisurely manner.

NATURAL CONTROL

In insect control the owner has a natural force which is always at work helping him. This force is often referred to as Natural Control

and consists of the natural enemies of injurious insects, divided as follows:

(1) Parasitic insects
(2) Predacious insects
(3) Parasitic fungi
(4) Birds
(5) Mites
(6) Bacteria

PARASITIC INSECTS

Under beneficial parasitic insects we find a large number of four-winged, wasp-like insects belonging to the order *Hymenoptera*. There

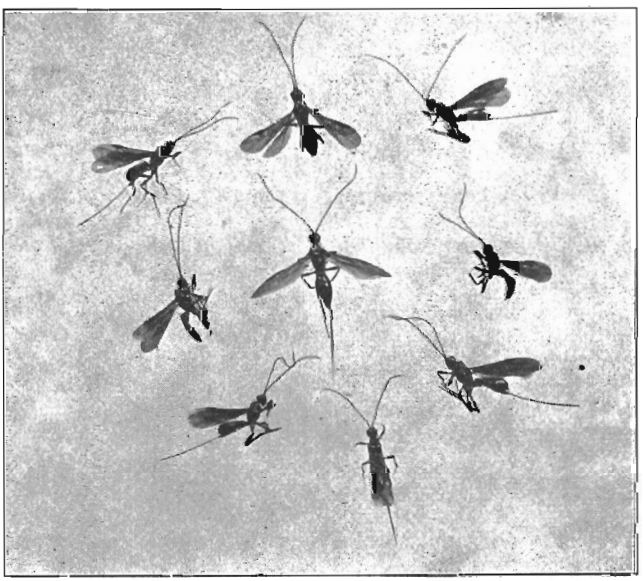

Fig. 3. Hymenopterous parasites.

are parasites belonging to other orders of insects but as far as known they do not affect bark-beetles so will not be treated here.

These parasitic wasps belong to many families and genera; the two most important groups known to prey upon bark-beetles are the ichneumon-flies (Fig. 3) (*Ichneumonoidae*) and the chalcis-flies (*Chalcididae*).

During the warm summer days one can see small red- or green-bodied insects hovering over infested logs or about infested trees. These are the parasitic flies or wasps which light on the bark now and then and move about, carefully examining the cracks and crevices. Finally selecting a favorable spot the insect proceeds to drill a hole through the bark by the use of a long needle-like structure which protrudes from the lower surface of the body near the end. This is known as the

ovipositor and is composed of three parts, two of which fit closely together forming a slender tube, within which is the third, needle-like tube, through which the eggs are forced into the cavity under the bark. The females alone possess this long ovipositor. They also possess sensory organs by which they are able to locate the working insects under the bark. When one of these is located the female inserts her ovipositor and by a continual up and down motion of the body drives this needle-like structure through the bark until it enters the insect mine. She then forces one or more eggs into the cavity. The egg hatches into a minute white grub which attaches itself to the larva or grub of the bark-beetle and lives upon the juices of its body. About the time the bark-beetle would normally pupate it dies from the attack of the parasite and upon examining the pupal chamber one will find, instead of the naked pupae of the beetle, an oval, parchment-like cocoon within which the parasite is slowly changing to a wasp. This parasitic wasp will later emerge to deposit eggs in other galleries and destroy other bark-beetles.

Little study has been made of the parasitic insects which prey upon the Western pine beetle, but we have a considerable list of parasites which attack other scolytids and no doubt the Western pine beetle has its parasitic enemies. It is possible that methods for artificial breeding may be developed so as to increase the parasites to such an extent that they will have a marked influence in reducing the pest.

A brief general description of the two important groups of parasites may not be out of place since the forester will be interested in watching for the friends nature furnishes him.

The Ichneumen-flies (super-family *Ichneumonoidea*). Insects with two pairs of transparent wings, long slender bodies usually black with yellow bands (the larger forms) or of a reddish color (smaller forms). Attached to the under side of the body near the last segment of the female is the long, bristle- or needle-like ovipositor which is usually as long or longer than the body and will serve as one of the best distinguishing characters. In size these parasites range from minute forms scarcely more than one-eighth inch long to very large forms having a body two and one-half inches long and an ovipositor measuring six inches in length. The larger forms are parasitic on the larger wood borers and also on many caterpillars, while some of the forms of small or medium size prey upon the bark-beetles.

The Chalcis-flies (family *Chalcididae*). The members of this group are usually very minute insects with four transparent wings fringed with hairs; many are not more than one hundredth of an inch in length and very few are over one-quarter of an inch in length. They are usually metallic black, green, blue, or yellow in color, head large and body more compact than in the ichneumen-flies. Many are parasites on insect eggs but others attack the immature stage of insects including many forest forms. This group is not nearly so important as the *Ichneumonoidea* in keeping bark borers under control, nevertheless it does exert a certain influence which must not be overlooked.

PREDACEOUS ENEMIES OF BARK-BEETLES

Under beneficial predacious insects are classed those insects which capture and devour their prey. Here are found several species of beetles

belonging to a number of different families, also one family of flies. A short discussion of the more important families follows:

The Checker beetles (family *Cleridae*). Small grayish beetles (with red under-parts) which run about infested logs, branches, and trees with great rapidity. Their legs are long and strong; mouth parts greatly developed for grasping and killing their prey. The adult beetle captures adult scolytids, and the clerid larvae are found living under bark and in insect mines feeding on the eggs, larvae, and pupae of the bark borers. These beetles are quite common throughout the yellow-pine regions of Oregon and undoubtedly destroy large quantities of the bark borers in all stages.

Family Trogositidae. This group has no common name, yet is one of the most common as well as one of the most easliy recognized groups we have. The adult beetle is about ½ inch long, bright metallic blue or green in color, more or less flattened, and with strongly developed, grasping mouth parts. The adults move but slowly over the infested logs and capture their prey more by surprise than by quick movements. The larvae, as with the checker beetle larvae, live beneath the bark, preying upon the immature borers.

There are other beetles* found under the bark and on infested material but they either occur rarely or their habits are not well known. They may destroy some borers at one stage or another or they may be simply living on the sour sap of the trees or on the excrement in the burrows.

Robber Flies (family *Asilidae*). These are a group of medium- and large-size two-winged flies belonging to the order *Diptera* (true flies), The adults are black or yellow hairy creatures of ferocious appearance, which dart about capturing their prey on the wing, and during the season when vast numbers of bark-beetles are flying the robber flies capture and destroy large numbers of them.

PARASITIC FUNGI

There is a group of parasitic fungi technically known as *Entomophthoraceae* which prey entirely upon insects. Ideal conditions for certain species of these fungi are found in the damp and often sour galleries of bark-boring beetles. Although little investigation has been made concerning the species which attacks the Western pine beetle there is ample proof that the fungi are capable of destroying whole broods of closely related species of bark-beetles. The field offers excellent opportunities for working out methods of artificial propagation of a fungus which will attack the Western pine beetle and for devising means of spreading it throughout infested areas.

BIRDS

Because of their large size birds attract attention and almost every forester knows that they destroy large quantities of wood-boring grubs each year. Woodpeckers may be observed almost any summer day dig-

* Families: Cucujidae, Histeridae, Staphylinidae, Colydiidae, and Cicindelidae.

ging away at infested trees, seeking the wood-boring grubs which seem to be such a delicacy for them.

There are a number of species of the woodpecker group found in the yellow-pine regions of Oregon, but they are far less numerous than they were a few years ago, so that the effect of their good work is decreasing year by year instead of increasing.

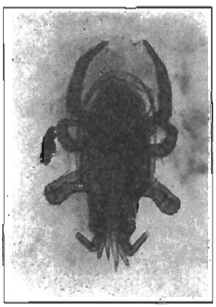

Fig. 4. Serius safroi Ewing. A mite which preys upon immature bark-beetles.

ACARINA OR MITES

Mites found in the mines of bark-beetles are minute, pale yellowish or white, semi-transparent (Fig 4) creatures with eight legs and usually with spines or hairs. Some species seem to live in perfect harmony with the bark-beetles while others are parasitic on the larvae and pupae of the latter. It is not unusual, upon exposing broods of bark-beetles, to find the immature stages of the beetles covered with these minute mites. In obtaining their nourishment the mites suck the vitality of their hosts, ultimately killing them. Whether it is possible to propagate and spread these mites artificially remains to be determined.

PARASITIC BACTERIA

While very little is known about the bacteria parasitic to insects, there are a few well-known instances, some of economic importance. Either the insects or their larvae may be attacked and destroyed. The attack may occur naturally or may be brought about artificially. Bacilli, micrococci, and streptococci are the most common although at least one disease of bees has been described as a filterable virus*. It is probable that there are many bacteria parasitic to insects which have not been described.

ARTIFICIAL OR APPLIED CONTROL

Although nature has furnished certain means of controlling injurious insects, man in his various operations has upset the balance of nature and hence he must now help nature's forces to destroy the injurious pests.

At present the methods employed in combating bark-beetles are crude, expensive, and not altogether satisfactory, but until new and better means are worked out, in a practical way, we must use what have been tried. That these tried methods have been successful to some extent cannot be denied; the data on actual work accomplished in certain areas prove that the beetles can and have been reduced from epidemic infestations back to normal, or even below normal, at a cost which was not prohibitive.

* Filterable virus is the name given to a class of the most minute organisms which can pass through the finest of unglazed porcelain filters.

Following is a review of the methods advocated and used, with comments on their practicability and usefulness in the pine regions of Oregon.

GENERAL PRINCIPLES OF CONTROL

The life-history, seasonal history, and habits of the species responsible for the damage must be known and taken into consideration if the maximum result is to be obtained from a minimum outlay. For instance, with the mountain pine bark-beetle it is sufficient to bark the tree to destroy the brood. With the species we are considering, the Western pine beetle, removing the bark will get only a very small percentage since the larval stage is spent, not between the bark and the wood, but in the outer portion of the inner bark. Hence, destruction of the bark by burning or other means is one of the most essential points.* The time to carry on control operations depends largely upon seasonal history, for if we are to get the maximum destruction of beetles for any given amount of work, operations must be conducted while the whole brood is at home, and not after the early developing individuals have flown; in other words, best results are obtained by carrying on control work from the time the beetles cease activity in the fall until they resume activity in the spring. From a study of the Western pine beetle we find the season of inactivity is approximately from September 15 to April 15 but varies from ten days to two weeks according to altitude and season. An early spring will of course bring on an early activity of the broods, but the above dates may be assumed correct for most work in Oregon.

When we know the insect with which we have to deal, its habits, life-history, and seasonal history, we are ready to consider the various methods by which it can be checked or controlled.

WHEN IS ARTIFICIAL CONTROL WARRANTED?

Under our present system of control we are warranted in attempting the control of widespread and serious infestations of *Dendroctonus* beetles only when a thorough investigation shows clearly that the cost of the operation will be fully justified by the value of the timber actually endangered and that the control work will be effective in checking the spread of the infestation.

METHODS ADVOCATED FOR CONTROLLING BARK-BEETLES

(1) **Removing bark from standing trees** by means of specially constructed tools. This method is not applicable to our trees on account of their height, and the fact that *Dendroctonus brevicomis* works not only in the lower but also in the middle and upper trunk.

(2) **Destroying the broods without removing the bark.**

(a) Convert the logs into lumber and burn the slabs.

(b) Place logs in water.

*A recent discovery by the Bureau of Entomology, U. S. Department of Agriculture, that the broods may be destroyed by exposing the bark to the direct rays of the sun shows great promise and will be thoroughly tested out during the coming season.

(c) Pile the logs and scorch the bark sufficiently to destroy the broods.
(d) Score the upper side of felled trees to allow water to get under the bark and destroy the broods.

Method (a) under (2) is, of course, a logical method. Wherever possible logging operations should be directed into infested areas and a special effort made to cut all infested trees after September 1, and to have them through the mill and the slabs destroyed before April 15.

Method (b) under (2), destruction of broods by water, is to be recommended. Infested trees near lakes or streams should be cut, bucked into convenient lengths and put into water even though regular operations are not being conducted in the vicinity. The water will kill most of the broods and will prevent other borers from entering. It is of course cheaper than barking and burning.

The method (c) under (2) can be employed with small, thin-barked species, such as lodge-pole pine, but is not applicable to large, thick-barked species such as yellow and sugar pine.

The scoring method, (d) under (2), is not at all reliable, even for species whose larvae spend their life in the cambium, and should not be used with any species which lives in the bark.

(3) **Trap-tree method of control.** This method consists of deadening a tree by girdling during the time of flight of the beetles on the assumption that the beetles will gather to it in preference to attacking green timber. It is true that the Western pine beetle will come to such trees to a certain extent, but the number of trees required to attract the broods, even in a normal infestation, over the large areas, precludes the use of this method for primary control in Oregon forests. Once an area is cleaned, however, the trap-tree method is strongly recommended as a means of keeping the area clean.

(4) **A modification of the Trap-Tree Method.** It appears that normally the majority of our bark-beetles prefer dying bark and for this reason will breed in cut logs, stumps and slash, in so far as such material is available. In such material they breed in vast numbers so that unless the cutting operations are very extensive and increasing from year to year the beetles soon become so numerous as to be unable to find sufficient material of this character in which to breed. When this stage is reached swarms of them migrate to nearby healthy timber and become a menace to all green timber in the stand. If cutting ceases suddenly there is sure to be a serious and often widespread infestation.

On the other hand this slash and cull material can be used as a trap for the beetles and if all slash is carefully piled over the stumps and cull logs and burned at the proper season vast numbers of the beetles will be destroyed and the greatest of fire risks is removed at the same time. In the case of beetles having a single generation a year, burning of all useless material in the fall is to be recommended. In the case of beetles having more than a single brood a year, burning in the fall will get only approximately 50 percent of the insects since the first generation emerged in late summer. It is therefore recommended that, where the fire risk is not too great, all possible slash, etc., be burned

late in July or early in August, and that a second clean-up and burning take place sometime between October and April. If this plan can be followed out it will keep at a minimum the infestations in the green timber adjacent to the operations and will prevent the spread of the beetles to other tracts. Just how far beetles will be attracted to fresh slash has not been determined but it is a matter of some miles.

(5) **The 50 Percent—75 Percent Method.** It has been recommended that it was necessary to destroy only 50 to 75 percent of the beetles to get complete control, also that "it is not only useless but unnecessary to attempt the complete extermination of one or more species of the beetles within a given forest."

It is not necessary to destroy every beetle; under our present system that is impossible. The destruction of every brood, however, should be the aim. The 50-to-75-percent destruction method has failed in many cases and simply necessitated the work on a given tract being repeated the following season. If, however, it is a question of destroying 50 percent of the broods over a whole basin as against getting 90 percent over one-half or less of the area, in a single season, the 50 percent method is preferable.

(6) **Use of Portable Saw Mill in Control.** Although this method has not been used in Oregon, it seems that it is worthy of consideration. Since much of our yellow pine timber is in open, often easily accessible areas a portable mill might well be run into areas of heavy infestation, the beetle trees cut and converted into lumber on the spot. At the present price of lumber and with the modern truck for transporting the lumber the operations should be carried on at a substantial profit.

Large owners not desiring to take up this phase of the work might sell infested stumpage at such a figure as to attract the small operator to the holdings.

EXAMPLE OF SUCCESSFUL CONTROL

The Ochoco National Forest Project

The control work carried out in the Ochoco National Forest by the United States Department of Agriculture Forest Service in 1912-1913 is one of the best examples we have by which to judge operations. The work was conducted for the purpose of determining: (1) whether or not extensive infestations of the mountain pine beetle (*D. monticolae*) and the Western pine beetle (*D. brevicomis*) in both lodge-pole (*Pinus contorta*) and yellow pine (*P. ponderosa*), could be controlled by artificial means; (2) the advisability of further efforts to control infestations on the National Forests; and (3) the best methods for control work.

The body of timber selected was almost ideal for the purpose; it is well isolated, except in the east side where it joins up with the Malheur Forest. In previous projects, the fact that surrounding infested timber furnished ample opportunity for reinfestation, prevented the obtaining of accurate data on the value of the work done.

PROCEDURE

One or more trained men, capable of detecting infested trees, must be employed as markers. The area to be treated is divided into small units, each unit of sufficient size to keep a treating crew busy for several days. The marker crosses and recrosses the unit in such a manner that every tree is examined and the infested trees marked. (Where two different beetles are to be dealt with each species has its individual mark.)

The Treating Crews. It was found that for large operations in yellow pine timber a crew of six to eight men was preferable, while in small operations where the timber is small (lodge-pole pine) crews of four to six men were best.

On the Ochoco Project crews of six and eight men were used, organized as follows.

Six-man crew	Eight-man crew
Two fallers	Two fallers
One bucker	One bucker
One limber	One limber
Two log and brush pilers	Four log and brush pilers

The eight-man crew obtained the best results, since in the six-man crew the log and brush men were unable to keep up with the fallers. In each case one man was made crew foreman with a slight increase in pay.

Felling. Two experienced men are essential for this phase of the operation since the way in which the trees are felled has a marked influence on the work of the other members of the crew. Trees should be dropped parallel, so that the limbers and buckers can work to better advantage. Stumps should be cut as low as possible, under eighteen inches, and either peeled or brush piled over them and burned. The fellers tally the trees.

Bucking. Experience proved that one man, using a good five or five-and-one-half foot stiff saw, could buck as many lodge-pole pine logs as two men handling one saw, and he had no difficulty keeping up with the fallers.

Limbing. A good axman who will cut the limbs close to the trunk, so as not to interfere in piling, is the only requirement.

Piling. In order to insure burning the bottom tiers of logs are laid flat on the ground in such a manner as to prevent cross currents of air. Piles should be made as large as possible and all logs piled parallel in order to get a good burn. Slashing may be piled on top of the logs or to one side for burning.

Barking Yellow Pine. Because of their size and value large yellow pine logs were peeled and the bark infested with *Dendroctonus brevicomis* burned with the slash. The limber, bucker, and pilers work together when treating large yellow pine. An effort should be made to drop the trees across some object which will enable the workers to peel the under side of the trunk. Axes were used in removing the bark. Sections of bark free from infestation are left as traps, to be removed and burned later.

Burning. When weather conditions permit, the logs and brush are burned as soon as piled, otherwise a special burning crew will follow

up as soon as favorable conditions prevail. If the regular crew is doing the burning, the piles should be fired in the morning or at noon as the men go to work and chucked up in the evening as they come in.

Windrowing. If care is taken in forming the windrows, the limbs and bark will burn and char the logs sufficiently to kill the insects. The logs usually remain on the ground, but by this method the cost of the operation is reduced.

Use of Horses. Horses were used for skidding and piling logs and the experiment was found satisfactory in open country which is comparatively free of brush.

The advantages of using horses are:

(1) Material decrease in cost of bucking logs (larger logs)
(2) Slight decrease in cost of piling
(3) Material decrease in cost of skidding
(4) A saving of man power in handling the logs
(5) A decrease in cost of burning (Piles are larger and fewer in number.)

The following organization was used.

1 span of good horses or mules
1 driver
2 log pilers
1 swamper (dispensed with where there is no brush)
4 fallers (2 crews)
4 limbers
2 single-man buckers

The limbers and buckers endeavor to pile the brush so as not to interfere with the work of the team, and the fallers, by using care, can place the trees parallel and far enough apart to lessen the work of the other members of the crew.

Care of Tools. Each man was charged with the ax he used and was responsible for keeping it in shape.

A saw filer kept the saws in shape and charged them out to the crews.

Freighting. Part of the equipment and some supplies were freighted in over the snow, reducing the cost. A six-animal freight team was kept on the road most of the time hauling in provisions and men from Prineville, a distance of sixty miles over very bad roads.

Camps and Personnel. Preliminary examination and location for camps was made April 10. The first crew was sent in on April 17-22, and actual work started about May 1. About sixty men were employed. It was found that one and one-half to two miles was the maximum distance men should be required to walk to work.

The following rules and regulations were found necessary by those in charge and are given as a guide to managers of private operations.

RULES AND REGULATIONS GOVERNING EMPLOYEES

in

INSECT CONTROL WORK

Ochoco National Forest

I. **Wages** $2.00 per day with board (8 hours' actual work per day). A charge of 25c per meal will be made when employees are in camp performing no duties, except Sundays, on which day no charge for board will be made. Men will travel to and from place of employment on their own time.

II. **Pay Rolls** will be made up and sent into the office at the end of each month. Meals will be served at regular hours. No meals will be served to employees arriving late, unless special arrangements have been made with the officer in charge of the camp.

III. **Employees** will not be permitted to loiter in the cook tents.

IV. **Transportation** to camp will be provided by the Government. Transportation from camp to Prineville will be provided by the Government at close of season. Employees leaving camp for any reason before the close of the working season must provide their own transportation out, or take advantage of freight teams leaving the camp. No special trips will be made.

V. **Baggage** and **Personal Equipment** to be hauled into camps by Government teams is limited to 100 pounds per man.

VI. **Employees** are expected to furnish their own beds and personal equipment such as towels, laundry soap, etc.

VII. The **Government** furnishes shelter in the form of tents and all equipment such as axes, saws, etc.

VIII. **No dogs, firearms, or liquor** will be permitted in camp.

IX. **Employees** will not be permitted to turn horses into Ranger Station pastures.

X. **No bankings of** earth or moisture-holding material which will tend to rot canvas will be permitted around the base of Government tents.

IX. **Government Camps** must be kept in a clean and sanitary condition.

FOREST SUPERVISOR.

COST DATA

I. Segregated Cost of Operation per M.B.F. and per Tree

Segregation	Total cost	Cost per MBF	Cost per tree
1. Marking, etc. (Wages only)	$ 300.00	$0.162	$0.025
2. Felling (Wages only)	676.08	.365	.052
3. Bucking (Wages only)	341.61	.184	.026
4. Limbing (Wages only)	677.27	.366	.053
5. Piling logs and brush (Wages only)	1355.65	.732	.105
6. Burning (Wages only)	338.64	.183	.026
7. Supervision and travel (Wages only)	438.06	.257	.035
8. 2/3 Freighting (wages and all expenses)	341.84	.185	.026
9. Moving camp and road repairing (Wages only)	78.75	.042	.006
10. Field equipment (33-1/3%) depreciation)	137.52	.074	.010
11. Meals (including cook's wages, 1/3 of freighting, etc.)	2,098.69	.163	1.133
Total field	$6,784.11	$3.663	$0.527
12. Office work	38.90	.021	.003
Grand total	$6,823.01	$3.684	$0.530
Value of equipment on hand	$ 315.05	.....	.....
Total expenditures	7,138.06	.....	.....

II. Total Segregated Cost of Operation

Segregation	Total
1. Cost of labor	$3,903.51
2. Cost of provisions	1,569.41
3. Total cost of equipment (field and cooking)	472.57
4. Total cost of freighting	512.75
5. Travel expense for forest officer	41.76
Total	6,500.00
6. Cost of forest officer's time in field	599.16
7. Cost of forest officer's time in office	38.90
Grand total	$7,138.06

III. Segregated Cost of Board

Segregation	Total
1. Wages for cooks	$ 338.37
2. Cost of provisions	1,569.41
3. Cost of cooking equipment (33-1/3% depreciation)	20.00
4. Cost of 1/3 of the freighting	170.91
Total	$2,098.69
Total number of meals served	6,883.
Average cost per meal	$0.305
Cost of food per man per day	.684
Total cost of board per man per day	.915

The Ochoco Project, dealing principally with Dendroctonus monticolae in lodge-pole as well as yellow pine does not present the identical situation which will be found in yellow pine infested by D. brevicomis.

A total of 12,873 trees (1,881 yellow pine; 10,992 lodge-pole pine) were treated at a cost of $6,500 or at an average cost of approximately fifty cents a tree. The total volume of treated timber was 1,852,000 board feet at a cost of $3.50 per thousand. This timber was scattered over 3,600 acres of land and the area benefited was 12,000 acres.

In other words the heavy infestations were checked at a cost of one-half cent an acre.

CONTROL ON PRIVATE LANDS

The Ochoco Project was a Government operation but many of the methods used are applicable to private holdings. The methods employed by the Klamath-Lake Counties Forest Fire Association with some of the results obtained are given below.* Mr. Kimball says:

> Our plan comprehends a constant watch over the entire forest and special treatment of such areas as show a beginning of a serious infestation. * * * That the timber protected by this association shows much less beetle loss than that of our neighbors is satisfactory evidence of the advantages in preventing the start of those heavy centers of infestation.
>
> The fact that pine beetles annually destroy a considerable amount of green standing pine timber is known to a majority of the large timberland owners. But the fact that it pays to fight this forest enemy is not so well recognized. Most of the efforts of private owners to eliminate the beetle pest have been caused by some spectacular evidence of beetle destructiveness. A considerable area of bug-killed timber naturally is alarming to the holder of a tract, while a sporadic infestation is more likely to escape attention, even though each represents a concrete loss. Therefore, usually private control projects have been abandoned when the centers of infestation were removed.

* Data obtained through the courtesy of Mr. J. F. Kimball, secretary-treasurer of the Association.

The economy of fighting fire and beetles with the same organization should be apparent. Beetle-control operations cannot be carried on in the summer because the bugs are then in flight and also because it is not safe to destroy tbe broods with fire. Yet during the intervening seasons this work can be prosecuted with good results. Hence, it is possible for an organization to provide work for its patrolmen for most of the year. Thus capable woodsmen seek service with it. In time each man becomes a bug expert, that is, expert so far as locating and treating infested trees is concerned. Tbis association has originated the following method in fighting the beetle: Tbree men constitute a crew, each can run compass, each is a lumberjack, each knows a bug tree; one man runs compass through the center of a forty, one man weaves back and forth about a tally to the left of the compassman carrying a falling saw, and one man works about a tally to the right of the compassman; each man carries an axe with which to test suspected trees and to bark tbe infested trees; all are watching for bug trees, and wben one is located, before proceeding any further with the examination, they fall and bark it and then burn the bark in order to destroy the brood of beetles; consequently when tbe cruise is finished the timber bas also been treated.

The advantages of employing patrolmen in the summer who are expert in locating and exterminating destructive beetles are twofold. By furnishing employment for ten months in the year we secure for a reasonable wage a high type of woodsman, proficient in fire fighting and who knows the bug game. Without in any measure detracting from their efficiency as fire patrolmen, and without any added cost for fire protection, they are able to keep check on our entire forest and know exactly where the beetle is doing damage. It is readily apparent that we can not search out and destroy every brood in our forest, but we are able to head off concentrated attacks of many broods (known as centers of infestation) from which radiates tbe destructive work of tbe beetle in its most alarming aspect.

Sufficient time has elapsed to reveal in detail the complete check we made on beetle destructiveness there (Pokegama Plateau), and the immense advantages which accrue from intelligent treatment of this pest. Mr. William P. Hopkins, one of the owners of a tract of approximately 40,000 acres, made a thorough investigation of his timber this year. From bim may be obtained confirmation of my report to you that we have effectually eliminated beetle destruction on the Pokegama Plateau.

The present conditions of the great belt of pine timber in the Jenny Creek Plateau is a remarkable evidence of the value of beetle control. A loss which before our protective work was tremendous in the aggregate is now almost entirely confined to isolated trees on the edge of the tract.

I do not hesitate to say that pine beetles have destroyed millions of feet of some of the best timber. For instance on Section 19 in Township 39 S., Range 5 E., more than 600 matured yellow pine trees have been killed in the past twelve years. It is probable that a cruiser could find some dying trees in the belt now, but it would require considerable examination.

The work in Unit 1 is now complete and the three years' work altogetber has cost tbe members $7,420.38, or practically four cents per acre. It may be necessary to go over this tract again at some future time, but it does not seem likely.

The present methods of beetle control are crude. * * * The field for investigation of better ways of fighting tbis pest should certainly be attractive.

Mr. Kimball is a forester of long experience and has found that by using a few men during that portion of the year not devoted to the fire situation, he has been able to keep down infestations on portions of the holdings of his Association. One crew of 3 or 4 men cannot locate, cut, bark, and burn the infested trees over a very large section in a single season; hence re-infestation occurs and the task seems to have no limit. If a method can be devised so that this same small crew can cover a much

larger territory and at the same time do the work thoroughly it seems that the losses may be reduced to a negligible quantity. To accomplish this result several things are necessary. There must be cooperation among all operators in yellow pine so that all slash, etc., will be destroyed in accordance with plan 4 (pp. 23-24), for it is impossible to clean one area or unit, large or small, without reference to the rest of the forest.

It is desirable that the work of all parasites be carefully studied in order to determine whether or not these natural enemies can be made to destroy a greater percentage of the beetles. By the use of these two methods it may be possible to reduce the number of broods so that a small crew can cover from two to ten times as much area as is possible at present.

There is also a possibility that a method may be devised whereby the broods can be destroyed by electricity without barking and burning. If present experiments prove successful this will reduce the work of the treating crew 75 percent, or in other words will reduce control costs 75 percent, and will allow a small crew to cover a much larger territory in a given time.

Heretofore control work has been stopped in late spring or early summer, due to the fire hazard from burning the bark. A recent discovery by the Bureau of Entomology, through its Forest Insect Station at Ashland that broods of the Western pine bark-beetle may be destroyed by exposing the inner surface of infested bark to the direct rays of the sun, will be thoroughly tested out in various parts of the country during the coming season and if this theory proves successful it will be possible to continue control operations throughout the summer.