THE INSECT PROBLEMS OF LODGEPOLE PINE FORESTS OF EASTERN OREGON AND WASHINGTON

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INTRODUCTION

With the increase in value of the lodgepole pine stands in Eastern Oregon and Washington, in recent years, has come the problem of protecting these trees from various destructive agencies.

The purpose of this paper is to present the measures used in protecting these stands of lodgepole pine from their most important insect enemies.

Range and Character of Lodgepole Pine:

The Lodgepole pine forests in Oregon and Washington are found between sea level and 6000 feet elevation. There is the coastal form which is not important economically and the mountain form. The latter is a medium sized tree that grows on a variety of soil types, but its best development is made on well-drained sandy or gravelly loam soils. It grows in either pure, dense, even-aged stands or in mixed stands with other conifers. Its most common associate in Eastern Oregon and Eastern Washington is Ponderosa pine(8).

Lodgepole pine, due to its hardiness and aggressiveness, is capable of restocking burns or cut-over lands in a comparatively short time. This ability to restock to pure dense stands brings about a stagnation and very slow growth(8).

East of the Cascade Mountains in Oregon and Washington lodgepole pine is becoming an economically important species from the standpoint of utilization and aesthetic qualities.

There are 691,218 M bd.ft. of lodgepole pine in Eastern Oregon and 475,749 M bd.ft. in Eastern Washington.

The acreage of the lodgepole forests, containing 50% or more of lodgepole pine, is divided into three types, namely:

EASTERN OREGON

Lodgepole pine, large 12" or more DBH	57,555 Ac.
Lodgepole pine, medium 6"-10" DBH	1,324,900 Ac.
Lodgepole Pine, small less than 6"DBH	241,085 Ac.

EASTERN WASHINGTON

Lodgepole pine, large, 12" or more DBH	29,155 Ac.
Lodgepole pine, medium, 6"-10" DBH	287,960 Ac.
Lodgepole pine, small less than 6"DBH	294,270 Ac.

Commercial Importance:

In some localities lodgepole pine is used quite extensively for cordwood. The tall, straight bole of trees grown in dense stands are very valuable, to the logging operator for hewn ties which are used largely on spur tracks. In some places it is used for poles; it makes a good looking pole but it case hardens as it seasons, making it very difficult for the linemen, because their spurs will not hold safely. On logging operations where lodgepole pine is mixed with other species, the larger trees are cut for saw logs. It makes a very good grade of #2 common lumber that can be mixed in with ponderosa pine lumber. The comminities or operations that depend upon the lodgepole pine forests for these various uses would be greatly handicapped if an insect epidemic should destroy their source of material.

Recreational Importance:

The lodgepole forests have great recreational value in that they are predominant in some of our greatest recreational areas. Large portions of the heavily used lake areas, like Diamond Lake, Crater Lake, and Elk Lake in Oregon, and Wallowa Lake and Lake Chelan in Washington, consist of lodgepole forests. If an insect epidemic should kill the forests in the vicinity of one of these important recreational areas, its aesthetic value would be greatly reduced. A snag patch is not a very restful sight, and it would require many years before a wound of that type would heal over.

A lodgepole forest that has been destoyed by insects is not only a loss along the lines of recreation and utilization, but it also creates a great fire hazard. Large areas of standing snags in a region where "dry" lightning storms are not uncommon (21) are not only dangerous to the immediate vicinity, but also to the surrounding stands of the more valuable ponderosa pine and to important watersheds.

Insects Attacking Lodgepole Pine:

Lodgepole pine is very susceptible to insect attacks of all types. In the range of the tree, there are nearly fifty different insects that work under the bark of the trunks, in the wood of the trunks, in small limbs and twigs, in the cones, or in the needles. (14)Of these, four are primary enemies, namely: Dendroctonus monticolae,

Dendroctonus valens, Ips oregoni (bark beetles), and Vespamima sequoiae (pitch moths), which are listed as primary insects of lodgepole pine (14) only one, Dendroctonus monticolae, the mountain pine beetles, is of economic importance in Oregon and Washington. One other insect, a secondary enemy of lodgepole, the lodgepole pine needle miner, Recuvaria milleri, is also very important.

Lodgepole Pine Needle Miner (Recuvaria milleri)

Description of the Moth

The lodgepole pine needle miner, Recuvaria milleri, is a moth. The adult is small and has grayish colored wings with an expanse of about one half inch. The forewings, the head, and the thorax are silvery gray, marked with black. The hindwings and the face are light brown and the abdomen white(19).

Hosts

At present, the only known hosts of the species are lodgepole pine and the Jeffery pine.

Life History and Habits.

The moths require 25 months, or one year and parts of two other years to complete their life cycle(19).

The adult moths emerge early June and are in flight until mid-August of every other year (1929-31 etc.). The moths appear in large numbers during the years of flight and swarm over the host trees. During the period of greatest flight they are pests to campers. They get into food and utensils(3).

The moth flights occur during the warmer part of the day and the eggs are deposited under the sheaths at the base of the needles. They begin to hatch early in August, or four weeks after having been deposited(19).

After hatching, the larvae crawl up the current year's needles and entering near the apex head towards the petiole of the needle. They mine only a short distance into the first needle and then hibernate for the winter. Feeding is resumed about May. They finish the first needle and enter the second one in the same manner by August. The larvae are practically full grown by late October and hibernate in the second needle during the second winter. In May they again resume activity, soon finish mining out the second needle and migrate to the third. After feeding in this needle for a short time, the larvae line the inside of the tunnels with silk in preparation for pupation. Here the larvae transform from pupae to adult. They start pupating in early June and the adult emergence begins early July (3)(19).

Control of the Needle Miner.

Applied Control.

In commercial forests, there is no economic means of controlling an epidemic of needle miners. Experiments made recently indicate that oil sprays applied just after the egg laying period will kill the larvae(7). This method could probably be used in recreational areas where the stands have a high aesthetic value.

Natural Control.

Natural methods are not of noticeable importance in controlling the insect. The larvae are exposed to their natural enemies during their two migrations to new needles. About 15% of each brood is destroyed by ten different species of hymenopterous parasites. Some birds feed on the moths during their period of flight. The most important bird is the pine siskin(3)(7)(19).

Extent of Damage.

Until recent years, the only outbreaks of the insect were reported from the lodgepole stands of the upper Tualumne River watershed in Yosemite National Park of California(7). Recently, however, there has been one large needle miner infestation in Oregon. That was one south of Bend on the Deschutes National Forest, 1931-35.

Although the needle miner does not kill the larger trees, there are two important aspects of the damage done. These are: (1) Lowering the vitality of the trees and thus increasing the susceptibility of beetle attacks. The defoliation of the tree causes a reduction in growth and decreases the ability to withstand the attack of bark beetles.(2) The large trees that are defoliated and the small reproduction that is killed, increases the fire hazard to a large extent. Large amounts of reproduction were killed in the Central Oregon infestation.

Mountain Pine Beetle (Dendroctonus monticolae)

The other and most important insect enemy of the lodgepole forests is the mountain pine beetle, Dendroctonus

monticolae, which is perhaps the most destructive of all the Dendroctonus beetles(5). It is economically important throughout the states of Oregon, Idaho, Washington, California, Western Nevada, and Northwestern Wyoming as well as Southwestern Canada.

Description of Beetles.

The parent adults are small, stout, cylindrical, black beetles nearly a quarter of an inch long. They are usually found in the egg galleries. When the larvae are full grown, they are about the same size as the adults. They are white and legless with small yellow heads. The pupae are found in cells within the inner bark. They are white with spines on the abdomen(14).

Hosts.

The insect is a primary enemy of western yellow, western white pine, and sometimes Engelmann spruce. It is very important in the stands of western white pine and lodgepole pine of the Northern Rocky Mountain region, Eastern Oregon, Eastern Washington, and the sugar pine stands of California(5).

Seasonal and Life History.

In April or May, the overwintering parent adult beetles extend their egg galleries or excavate new ones and deposit more eggs. The broods that overwintered in the bark begin to emerge in July, August, and September. The broods of larvae begin to pupate in late April and May and continue until September or later if the weather permits. The eggs deposited by the overwintered adults begin

to develop to adults in July and August.

After emerging from the parent tree, the adults begin to attack new trees, excavate galleries, and deposit eggs in August, September, and October. The larvae begin to hatch in August and transform to pupae and adults in September and October. Under favorable conditions a few adults may emerge in the Fall but the normal habit is to pass the winter in the host tree. There is just one generation of beetles a year, with a possible overlapping of the generations of three years during one summer(9).

Description of the Beetle Work.

The attack of the beetle is first noted by pitch tubes on the trunk of the tree and reddish boring dust in the crevices of the bark near the foot of the tree. Later the trees can be located when the foliage changes from a light greenish yellow to red.

If a section of the infested bark is removed, the long, straight egg galleries, filled with the boring dust, will be noted. The larvae mines branch from these galleries, and end in nearly circular pupal cells within the inner bark(14).

Types of Infestations.

Endemic or normal infestations of the beetles are found in practically all mature lodgepole forests. Such losses of timber are of no economic importance although destructive epidemic infestations may develop very rapidly from an endemic infestation(5).

Types of Trees Attacked.

The larger, thick barked, mature trees are the first trees to be attacked during an infestation. The beetles concentrate their attacks on clumps of trees. During an epidemic, 60%-80% of the total number of trees in the stand may be destroyed. There are no accurate data available for the volume of lodgepole which has been destroyed in the past decade. Observations over the past 30 years indicate that the lodgepole forests throughout this region are inevitably destroyed when they reach a certain stage of maturity. This is nature's method of harvesting. It indicates that this tree species should be handled on a rotation short enough to avoid beetle epidemics(5).

Control of the Mountain Pine Beetle.

History of Control Work.

The first control work ever attempted in lodgepole pine in the region was in 1910-14 on the Whitman and Ochoco National Forests in Oregon. Between 1910 and 1930 there have been fifteen to twenty different projects carried on with expenditures amounting to $300,000 and involving the treatment of over 300,000 trees on approximately 600,000 acres of land(5).

In recent years there has been only one project to control the mountain pine beetle in lodgepole pine. This was in the Crater Lake National Park and vicinity(18).

In the fall of 1923 the insect depredations in the Park came under observation and a detailed survey of

the extent of the infestations was made during the summer of 1924. In the part of the Park north of Crater Lake, nearly 200,000 trees on 22,000 acres of land had been killed. The beetles from this area were beginning to migrate into the more desirable recreational areas south of the Lake. The first control operations were carried on from May to July in 1925. A total of 4,291 trees were treated at a cost of $4,954.15. The disposal of slash and logs near roads and camp-sites brought the total cost up to $5,761.64. In 1926, the control work was carried on from May 17 to June 20, and later from August 8 to October 1. A total of 2,469 lodgepole pine were treated. The costs, including the clean up at camp-sites and along roads, amounted to $3,883.52. Treating was carried on between May 16 and June 28, in 1927. There was a total of 2,936 trees treated with a cost of $2,500. No clean up work was necessary. During the three year period, it was assumed that 11,774 trees were saved by the treating of the 9,696 trees(18). The infestation flared up again and during the summer of 1929, 23,544 trees were treated. In 1930, only a few areas, with a total of 9,947 trees, were treated. The project was expanded in 1931 with the treatment of 14,747 trees. In 1932, 20,311 trees were treated(20).

A rough estimate of the board feet of commercial timber in the trees treated in 1932 would be about 2,800 M. As a direct result of the control work carried on between 1929 and 1932 there was a 92.72% reduction in the number of infested trees(12)(20). A survey, in 1933,

showed that the epidemic was brought completely under control by the control work in the Spring of 1932.

Two Emergency Conservation Work Camps were established in the Park and as many as 200 men were used in the control work. They treated 5,794 lodgepole trees scattered over an area of 30,750 acres(11).

During the Spring of 1934, the Forest Service carried on control work in the Sun Pass area of the Rogue River National Forest. This area lies just Southeast of the Park boundary and had been endangering the control area in the Park for several years(2).

Types of Control.

The control of the mountain pine beetle can be divided into two different heads, namely: applied control and natural control. Each of these heads can in turn be divided into several methods and types.

Applied Control.

Solar Heat Treatment.

This method of treatment can be carried on only during the months of May, June, July, September and early October in Southern Oregon. Since the beetles are in flight during August, it is not advisable to attempt control at that time. This method is not applicable to the thick barked trees such as ponderosa pine and sugar pine, but very satisfactory results have been obtained in the thin barked trees such as western white pine and lodgepole pine.

The trees must be felled in a north and south direction. They are then limbed and topped just above

infested portion. They are left exposed to the sun for a period of from two to five days, the length of time depending upon the degree of intensity of the sun's heat. The trees are then turned in order to expose the remaining portion. Trees twenty inches or over, in diameter, are turned two different times, or about 120 degrees each time. The logs must be placed as close to the ground as possible and located so that unobstructed sunlight will reach them.

In the experiments carried on in Crater Lake National Park from 1925 to 1927 it was found that in order to obtain satisfactory results it was necessary to have an air temperature of at least 80 degrees F., and bark temperatures of the exposed logs ranged from 30 degrees to 50 degrees higher than the surrounding air temperature. In order to obtain killing temperatures it was necessary to have air temperatures of 80 to 85 degrees F and above. These temperatures insure a bark temperature of 120 degrees F. A minimum exposure of twenty minutes is necessary at this temperature to obtain lethal results. For temperatures below 120 degrees F two to three hours exposure are needed. At 110 degrees F anesthesia sets in and if prolonged the beetles will die.

Bark thickness at the base of the trees averaged one-half inch. Thirty feet above the ground it averaged three-eights of an inch and at the top with a diameter of four inches it averaged one-sixteenth of an inch.

The moisture content of the inner bark is not of

great importance in the death of the insects. It does, however, have a direct bearing on the bark temperature since it facilitates the penetration of the heat; therefore, the killing point is reached sooner in the moist bark.

It was discovered that the bark temperature on the south side of standing trees varied only a few degrees from the air temperature while on the north side of the tree, the bark temperature was 17 degrees below the air temperature. The temperature remained below 80 degrees in the standing tree while in a felled log nearby, the peak temperature was 123 degrees.

It was found that the angle of incidence of the sun's rays was a very important factor. Killing temperatures were obtained in the east one-third of the exposed portion of the log between the hours of 8:00 A. M. and 11:00 A. M. Between 11:00 A. M. and 2:00 P. M. the killing temperatures were obtained in the top one-third and these temperatures were obtained on the west one-third between 2:00 P. M. and 5:00 P. M.

On north exposures, in order to obtain the proper angle of incidence of the sun's rays, it is necessary to fell the trees in an east and west direction across the slope. By turning all trees twice instead of once and leaving them for a longer period of exposure, the desired results can be obtained.

In the Crater Lake National Park where this method of control was used extensively in an eight year battle against

an epidemic infestation of the mountain pine belt which killed a very large percentage of the lodgepole forests in the area between Diamond Lake and Crater Lake and then threatened the lodgepole stands in the south portion of the Park, it was found that while it was as effective as the burning method in controlling the beetles, it was also about 78 cents cheaper per tree. Along roads and near camp grounds where it was necessary to dispose of the slash the costs were about equal. The most important advantages of the Solar Heat method are: (1) There are no unsightly scorched trees left standing on the area, (2) It does not create a fire hazard by burning during the summer months(17).

Remove the Bark.

The heat of the sun is used in this method of beetle control also. The tree is felled and the bark removed from the entire infested portion. Since this mountain pine beetle spends its entire life in the cambium of the tree, it is easily killed by exposing the immature stages to the elements and their natural enemies. With the aid of "spud" bars, standing trees may be peeled up to 20 feet with less cost. The barking must be done before the insects reach the adult stage(3).

The peeling, without burning, has the same advantages the solar heat method has with respect to avoiding fire hazard and preventing the scorching of reproduction. It also has it's disadvantages, due to its thin bark, lodgepole is very difficult to peel. The peeling brings about

more expense and the slash and debris left on the ground increases the fire hazard.

Cut and Burn the Entire Tree.

Where groups of small trees are attacked it is often cheaper and quicker to cut the infested trees and with the aid of horses, pile them in the open where the whole pile can be burned(4).

Remove Bark and Burn.

In stands of thick barked trees or in shaded places where conditions will not permit the burning of the entire tree the logs are peeled and the bark burned alongside the log. This method is used extensively in control projects in ponderosa and sugar pine, but it has not been used to any great extent in lodgepole control projects.

Burn with Oil.

During the epidemic at Crater Lake, experiments with the method of burning with oil were made. The trees were felled in such a position as to raise them clear of the ground and all brush and green timber. They are then limbed up just above the infested portion. A small fire is then started at the base of the log and spray stream of oil directed against it. The fire is carried up one side of the log and down the other, then the log is given a one quarter turn and the unburned areas burned. A man with a shovel follows the burner and extinguishes any fire that should drop to the ground. The fire is never allowed to get a start on the ground. A log is considered as adequately burned when the bark scales show white ash margins.

The bark is scorched, the beetles killed and the fire completely out within five or ten minutes.

The equipment for this method consists of a five gallon back pack pump with a spray nozzle, oil with a gravity specification of 27 and a flash point of 225 degrees F. Five man crews are used, 2 fallers and 3 burners. The men alternate on the jobs. The operation costs $.68 to $1.00 per tree. Oil costs about five cents a gallon and ½ to ¾ gallon is used per tree(13)(6).

Burn Standing Trees.

It is not feasible to use this method of control on recreational areas because of the dead trees left standing. It has been used extensively in the Northern Rocky Mountains region in lodgepole pine infestations. It consists of spraying the bole of the standing tree with an inflammable oil.

Oil with a gravity specification of 32 to 34 and a flash point of about 160 degrees Fahrenheit is best adapted for this method. The oil can be sprayed to a height of 30 or 40 feet from the ground. Trees in which the infested length extends above 50 feet cannt be satisfactorily treated by this method(7).

Chemical Method.

The use of chemicals in the control of the mountain pine beetle was tried experimentally in the lodgepole stands in Montana and in the white pine in Eastern Washington.

In this method of control two cuts are made about three inches apart around the tree. The upper one should penetrate

the wood from ¼ to ½ inch. This enables the solution to enter the watercarrying vessels of the xylem. The bark is removed from between the two cuts and the wood is scraped to permit the application of a leak-proof collar. A narrow strip of bark perpendicular and above the peeled band is removed. The collar is attached to the tree with tin strips and shingle nails just below the upper cut. The collar is of rubberized material and when the poison solution is poured in, it stretches enough to hold the desired amount.

Several different poisons were used experimentally and powdered copper sulphate ($Cu\ SO_4 . 5H_2O$) was the most effective. During four years of the experiment an average bark beetle mortality of over 90% was secured. In western white pine this method can not be used in trees in which the attack is over 90 days old. This has been found to be the most practical method of controlling the beetles in western white pine. It is also effective in lodgepole pine(1).

Manufacture.

Where it is possible to do so, the manufacturing of infested logs is the ideal method of control. The infested trees should be cut low and the bark removed from the stumps. The logs should be removed from the woods and run through the mill as fast as possible and the slabs burned.

The slash may be disposed of in the usual manner of the locality(4).

Place Logs in Water.

Where there is danger of the broods emerging before the logs can be run through the mill, they should be stored in water. This will prevent a portion of the brood from emerging(4).

Costs of Applied Control.

The costs for each method varies with the conditions of the different localities. At Crater Lake it was found that the cost per tree for the solar heat was $.84. The pile and burn method cost $.93 per tree, and burning the trees with oil method varied from $.68 to $1.00 per tree, but where slash disposal was necessary, all costs were considerably higher.(17)(19)(20). The costs of burning the standing trees with oil would be considerably less because of the fact that there would be no felling or limbing to be considered. There were no available data on costs of any of the other methods.

Organization of a Control Project.

The first step to be taken on a control project is to make a preliminary survey. This should be done from September to November to determine the boundaries of the area and the centers of the infestation. If it is possible, logging operations should be directed into the area to remove infested timber. If not, control should be applied to the most infested districts first. Work should start at the head of infestation where the insects are migrating and work back on the area.

When the preliminary survey has been completed, the

method of control to be used must be decided upon. The project is then divided into areas. One area is to be treated each year or a part of each area each year. The areas are divided into units and these may consist of the portion of the area that one camp will cover in a season.

The number and size of camps to be established will be governed by the length of the treating season, the size of the area to be covered, and the amount of timber to be treated.

A board of control is usually in charge of the project and it should select a forest entomologist, area managers, and camp foremen. The entomologist has charge of the spotting crews and the area manager and foremen have charge of the treating crews. The purchasing of supplies, equipment, and procuring means of transportation and communication is handled by the board of control. They also set the hours and wage scale as well as set camp rules. The board of control, with the entomologist and the managers, determines the procedure to be followed in all the steps employed on the project.

Before the actual control work by any method is begun, certain information must be gathered. The spotters do this work. The type of spotting used depends on several things, namely: The amount and type of timber involved, the time available, the amount of information required, and the available funds. The topographic, the sample plot, and the sample strip methods are used in this work.

The topographic method is the least accurate and is

used in very steep country where other methods would be difficult to use and very expensive. One man works alone on topographic spotting. He works from a high point with a good topographic map, spotting the infested trees and marking their location on the map(14).

On more accessible areas, the sample-plot method is used. The spotters look the area over and select one or more sample areas which are representative of conditions on the entire area. The number of infested trees is determined on the sample area, then prorated over the area as a whole. Sample-plot crews should consist of three or more men. One man runs the compass and keeps the data on the infested trees located by the spotters.

The main difference between the sample-strip method and the sample-plot method is in the shape of the area covered. Instead of a square or a rectangle, the sample-strip covers a very long narrow strip. It takes in a cross-section of all conditions on the area(7).

Usually, three-man crews are employed. One compassman and two spotters. The spotters locate the infested trees and the compassman checks them as to location and number on the map. The width of the strips covered by the spotters varies with the density of the timber. In dense stands of lodgepole, the spotters sometimes work singly, on a compass line with a $\frac{1}{2}$ chain strip(7). After the spotters have determined the location of a sufficient number of trees to be treated, the treating crews go on to the area

using any of the various methods already described.

Natural Control.

Natural control is a very big factor in keeping endemic infestations from becoming epidemics. If it were not for the effects of adverse weather conditions and the natural enemies of the beetles our pine forests would have been destroyed long ago(4).

Temperature Changes.

The beetles overwintering in the bark have the ability to gradually throw off body moisture so as to protect themselves from the extreme cold weather that occurs in the pine region of Eastern Oregon and Washington. When there is a sudden drop in temperature, the beetles do not have time to regulate their body moisture. The excess moisture freezes and breaks their cell walls open, causing death. In studies taken in ponderosa pine after a sudden drop in temperature of 20 to 54 degrees below zero, it was found that from 50 to 90% of the overwintering brood were killed.

Predators and Parasites.

The woodpeckers do a lot towards destroying the brood in the tree during the winter. There are also many predatious and parasitic insects that destroy an unknown number of the adult beetles and larvae.

Preventative Measures.

There is the possibility of thinning out the dense stagnated stands in order to increase the thrift and vigor

of the remaining timber. This method has not been tried out, but its feasibility seems likely since it is nearly always the suppressed or over-mature trees that are attacked first.

Protection From Fire.

Complete protection from fire is a known preventative measure. Fire scorched lodgepole is particularly susceptable to beetle attacks. When right-of-way clearings are made in lodgepole stands, the burning of the slash should be done in the late Fall, Winter, or early Spring when the beetles are not in flight and cannot be attracted by the burning operations to the nearby stands of lodgepole. When beetles are attracted to slash fires they very often attack healthy standing trees in the vicinity of the fire. Care should be taken to avoid the scorching of standing trees. Scorching lowers the vitality of the trees and invites attack.

Avoid Injuries.

Avoid all possible injuries such as hacking, driving nails into the trees or pruning the standing trees. At Diamond Lake it was noticed that several of the trees that had been limbed up or hacked during the stringing of a telephone line were soon attacked by the beetles while nearby trees were not bothered. If pruning must be done, it should be done in the winter, if possible, and all brush burned before late Spring and the overwintering beetles begin to emerge.

CONCLUSION

With the increase in value of lodgepole pine, which is due mainly to the realization of a need for closer utilization of our forest products and an increase in the use of the forest areas for recreation, it has become more important that we protect these trees from their various enemies.

Large sums of money are spent yearly to protect the forests from fire, while insects, the silent workers, yearly destroy many times the amount that is destroyed by fire over a similar period. The principle of "Get them while they are small" that is used in fire protection also applies to the control of insect infestations. By applying that principle, large amounts of valuable timber can be saved.

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BIBLIOGRAPHY

1. Bedard, W. D.
Control of Mountain Pine Beetle by Chemicals
Journal of Forestry - Jan. 1938 pp 35-40

2. Buckhorn, W. J.*
Report of Forest Insect Conditions in Crater Lake National Park and Adjacent Areas of the Rogue River National Forest, Season of 1934.

3. Chamberlin, W. J.
Forest Entomology - Part II pp38-39

4. Chamberlin, W. J.
Introduction to Forest Entomology pp109-115

5. Craighead, J. C., et al
Control Work Against Bark Beetles In Western Forest and An Appraisal of Its Results.
Journal of Forestry - November 1931 pp 1009-1011

6. *Crater Lake National Park Insect Control Staff
Use of Oil in Pine Beetle Control Proves Successful on Crater Lake National Park Project.

7. Doane, Van Dyke, Chamberlin, and Burke
Forest Insects pp 38-53 and 78-79

8. Harlow and Harrar
Text Book of Dendrology pp 105-108

9. Hopkins, A. D.
Practical Information On The Scolytid Beetles of North American Forests.
U.S.D.A. Bur. Ent. Bul. 83 pt. I pp81-82

10. Keen, F. P. (Bureau of Entomology)
Annual Report of the Forest Insect Conditions in Oregon and Washington for 1933.

11. *Keen, F. P.
Report of the Mountain Pine Beetle Situation in Crater Lake National Park and Adjacent Lands of the Rogue River National Forest. Season 1933

12. Keen, F. P.
Report of Mountain Pine Beetle Situation in Crater Lake National Park and Surrounding Forest Areas. Season 1931 and Recommendations for Control, Spring 1932.

13. Keen, F. P. and Solinsky, F.
Pine Beetles Killed by a New Method
Forest Worker - Sept. 1932 pp 11-12

14. Keen, F. P.
Insect Enemies of California Pines and Their Control
Calif. Fut. 7 pp 33-35 and 104-105

15. Pacific Northwest Experiment Station
The Forest Survey of Eastern Oregon and Eastern Washington by Counties
April 1936 - August 1937

16. Pacific Northwest Experiment Station
Forest Statistics for Eastern Oregon and Eastern Washington
Forest Research Note #25 - Feb. 5, 1938

17. Patterson, J. E.
Control of the Mountain Pine Beetle in Lodgepole Pine by Use of Solar Heat.
U.S.D.A. Tech. Bul. 195 - 1930

18. *Patterson, J. E.
Final Report on the Crater Lake Park Control Project
November 1927

19. *Patterson, J. E.
Life History of Recurvaria milleri, The Lodgepole Pine Needle Miner, in Yosemite National Park, Calif.
Jour. Agr. Research - May 2, 1921 pp 127-141

20. *Solinsky, Frank J., III
Report on the Insect Control Project, Spring 1932

21. Westvelt, R. H.
Applied Silviculture in the United States pp 358

* (From the Crater Lake National Park files)

Acreage and Volume Statistics For Eastern Oregon

County	Acreage of Forests Containing 50% or more of Lodgepole Pine			Thousands Bd.Ft. Log Scale. Trees over 12" DBH
	Trees 12" or Larger DBH.	Trees 6"-10" DBH	Trees Less Than 6" DBH	
Baker		27,210	4,820	32,438
Crook	285	2,510	135	5,678
Deschutes	4,460	298,285	37,380	115,060
Grant	285	74,230	57,035	31,302
Harney		140		
Jefferson	610	21,475	1,085	6,177
Klamath	37,655	607,800	49,940	234,214
Lake	12,485	143,070	3,845	167,157
Morrow	90	12,400	3,775	3,515
Umatilla	85	17,355	31,360	15,418
Union	105	72,645	38,905	32,564
Wallowa	495	33,295	12,260	24,824
Wasco	990	10,430		21,744

Acreage and Volume Statistics For Eastern Washington				
County	Acreage of Forests Containing 50% or more of Lodgepole Pine			Thousands Bd. Ft. Log Scale. Trees over 12" DBH.
	Trees 12" or Larger DBH.	Trees 6"-10" DBH.	Trees Less than 6" DBH.	
Asolin				
Columbia				
Garfield		6,140	1,905	
Walla Walla				
Chelan	4,815	35,895	39,430	48,573
Ferry	350	17,770	69,515	20,378
Kittitas	4,300	7,100	3,595	82,492
Klickitat		335	290	1,339
Okanogan	4,615	175,865	101,210	103,875
Yakima	12,950	28,545	6,870	153,916