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CONTROL OF THE MOUNTAIN PINE BEETLE BY MEANS OF CHEMICALS[1]

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THE injection of various materials into trees and smaller plants is by no means a new idea, and tests have been made by various workers to determine the possibility of treating trees with toxic solutions to destroy detrimental organisms. This earlier work is reviewed in a contemporary paper by Craighead and St. George.[2] In the present article are reviewed briefly only those studies which have been made of tree injection as a possible method of controlling the mountain pine beetle (*Dendroctonus monticolae* Hopk.) in the northern Rocky Mountain region.

The first work[3] of this nature was done in 1926 in lodgepole pine (*Pinus contorta* Loud.) on the Bitterroot National Forest near Sula, Mont. During this and the four subsequent years approximately 600 infested trees of this species were treated on the Bitterroot Forest and on the Beaverhead National Forest near Wisdom, Mont. In 1930, following the work on the lodgepole pine project, the location of the experimental work was transferred to the Kaniksu National Forest in eastern Washington, and all injections since that year have been made in western white pine (*Pinus monticola* Doug.), on either the Kaniksu or the Coeur d'Alene National Forest. In all, 600 lodgepole pines and 1,254 western white pines infested with the mountain pine beetle have been treated with various poisons and methods of injection. In the following pages, a description of injection technique and a list of poisons are given, followed by a brief discussion of the practical application of the method, suggested equipment, and organization of control crews.

Injection Technique

Numerous adaptations of auger holes and girdles have been tested in the search for a practical technique to get the poison solution into the conducting tissues of the tree. At the present time the "saw-kerf rubberized collar" method is the cheapest, most effective, and easiest to apply for western white pine.

In preparing the tree for this type of injection (Fig. 1) two parallel saw cuts approximately 3 inches apart are made completely around the tree, as nearly horizontal as possible, and just above the butt swell of the tree. The upper saw cut should penetrate the wood from ¼ to ½ inch so that the solution may readily enter the water-carrying vessels of the freshly cut xylem. The lower saw cut barely penetrates to the wood and is made to facilitate peeling the bark in a narrow strip where the collar is to be attached. After the band of bark has been removed, the wood surface is scraped slightly to permit a tight, leak-proof application of the collar, and a narrow strip of bark is removed perpendicular to and above the peeled band, where the two ends of the collar are joined and fastened to the tree. The collar material is then attached around the tree by means of tin strips and shingle nails, and the ends of

[1]This paper discusses large-scale practical tests of methods for the application of chemicals developed experimentally at the Asheville, N. C., laboratory, as described in a contemporary paper.

[2]"Experimental work with the introduction of chemicals into the sap stream of trees for the control of insects." This Journal pp. 26-34.

[3]Studies prior to 1931, all of which are unpublished, were made by J. C. Evenden, A. L. Gibson, H. J. Rust, R. A. St. George, and D. DeLeon.

the collar are overlapped and nailed to the tree in the same manner. The bottom of the collar should be just below and as near the upper saw cut as possible so that all of the solution will be utilized (Fig. 2). Following this operation the poison solution is poured into the collar, which stretches sufficiently to hold the desired amount.

When deep scars, checks, or punky convolutions into which the collar can not be fastened are encountered in the peeled band, it is sometimes necessary to apply two partial collars, one above the other. This can be done by fastening the ends of the main collar on each side of the scar and preparing the tree and attaching a short section of collar above the main collar, merely taking care that the entire circumference of the tree has been exposed to the poison.

Poisons

Of the following ten different poisons tested at various times during the course of these experiments, the first five were used in both western white pine and lodgepole pine and the last five only in western white pine: Sodium arsenite (Na_2HAsO_3), zinc chloride ($ZnCl_2$), sodium fluoride (NaF), copper sulphate ($CuSO_4 5H_2O$), potassium cyanide (KCN), sodium arsenate ($Na_2AsO_4.12H_2O$), sodium fluosilicate (Na_2SiF_6), mercuric chloride ($HgCl_2$), ammonium fluoride (NH_4F), and sodium thiocyanate ($NaCNS$). Of these poisons, the last two were but recently tested and their effectiveness will not be determined until the injected trees have been examined at a later date. Of the remaining eight compounds all but copper sulphate, sodium arsenate, and zinc chloride have been discarded because of their ineffectiveness or their extreme toxicity and consequent danger in use. At the present time, copper sulphate, as regards low cost, effectiveness, and ease in handling, appears to be the best poison used.

Blue Stains

In general it can be said that blue stains which limit the use of this method elsewhere do not prevent successful application in western white pine. Satisfactory control can be secured in trees up to 90 days after attack by the beetles. Even so the period of control is thus restricted to the late summer and fall.

Practicability of Tree Injection

In considering this chemical method of control, both its effectiveness and its practicability as compared with those of present control methods must be considered. During the seasons from 1933 to 1936, inclusive, tree-injection experiments were placed on a regular control-project basis.

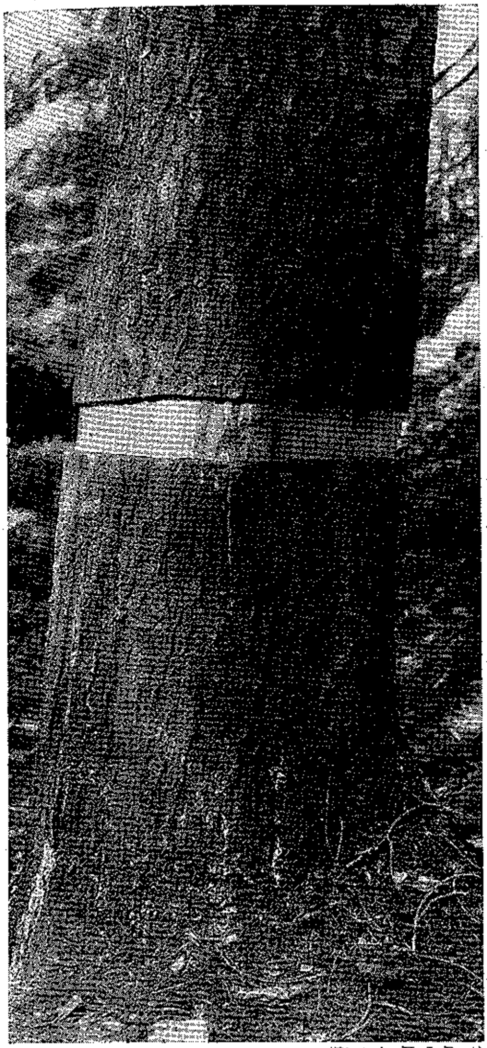
Ordinary laborers of the type regularly employed for bark beetle control work were used to determine whether they were capable of injecting the trees properly, and to ascertain the man-day accomplishment for comparison with that by the methods now in use.

The average bark beetle mortality of over 90 per cent which was secured in the injected trees during these 4 years is sufficient evidence of the ability of ordinary laborers to inject trees successfully. Table 1 gives a comparison of the man-day production by tree injection during 4 years with that secured by peeling or decking and burning the infested logs. The figure from the Kootenai National Forest is an average based upon 3 years' control

Table 1

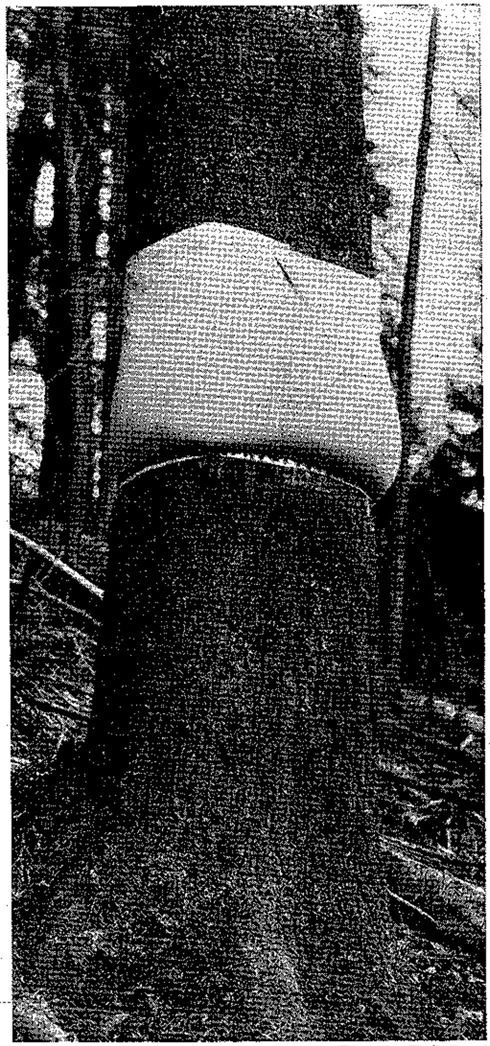
COMPARISON OF MAN-DAY ACCOMPLISHMENTS BY THE DECKING-BURNING AND INJECTION METHODS

National Forests	Method used and average number of trees treated per man-day: Decking and burning	Injection
Kootenai	2.00	----
Coeur d'Alene	2.17	----
Kaniksu and Coeur d'Alene		6.14



(Photo by H. J. Rust)

Fig. 1.—Tree prepared for application of collar. The bark has not yet been removed from the perpendicular strip for attachment of the ends of the collar.



(Photo by H. J. Rust)

Fig. 2.—Completed collar made from knitted rubber sheeting.

work involving five projects, and the Coeur d'Alene figure is an average of eight projects during 5 years.

Table 1 shows that the average production secured by chemical treatment is approximately three times as great as that secured by the older method of bark beetle control. Although it is more difficult to compare the two methods on a cost basis, this greater production must necessarily be reflected in the cost of control. Obviously on a cost basis those expenditures under labor, subsistence, supervision, and transportation would be lowered because the same amount of treating labor would be in camp only one-third as long as required for the burning or peeling methods. Equipment costs would be approximately the same, when the extra expenditure required by tree injection for poison, banding material, tin strips, and nails is included. In order to permit a general comparison of the two methods on a cost basis, the activity costs for the spring-control work of 1933 on the Coeur d'Alene National Forest are compared in Table 2 with the approximate cost had this work been done by chemical treatment.

In explanation of the comparative costs shown in Table 2, each item will now be considered separately. The cost of "Supervision" is reduced two thirds because this figure includes salaries of camp managers and contributed time by permanent officers. Since the project would last only one third as long had treatment been by injection, only one third of the charge need be made against tree injection. A similar explanation applies for the reduced cost under "Cookhouse labor" and "Treating labor", except that cookhouse labor should not be reduced so much because of the extra spotters. The cost of "Spotting" remains the same even though the project extends only one third of the time, because it is necessary to increase the number of spotting crews in order to spot the same area in the shorter time. Costs under "Camps" and "Travel" would also remain the same in both types of control. It is more difficult to arrive at a satisfactory comparison of the costs for "Subsistence", "Transportation", and "Equipment". Under "Equipment" the rental for tentage, cookhouse equipment, etc., is somewhat less for injection because the project lasts only one third of the time. Likewise the cost of equipment for injection work is about three quarters of that used for peeling or burning. On the other hand, extra tentage is required to house the additional spotting crews. Under "Subsistence" the same difficulty arises. The amount of food consumed by spotting crews would remain the same,

TABLE 2

COMPARISON OF COSTS FOR BURNING AND TREE INJECTION PERIOD OF WORK: MAY 15 TO JUNE 29 1933. NUMBER OF TREES TREATED: 4,552

Type of control	Decking and burning		Chemical treatment	
Item	Total expenditure	Cost per tree	Total expenditure	Cost per tree
Supervision	$ 2,324.34	$0.5106	$ 774.78	$0.1702
Spotting labor	7,688.69	1.6891	7,688.69	1.6891
Treating labor	8,240.26	1.8102	2,746.75	0.6034
Camps	1,964.32	0.4315	1,964.32	0.4315
Subsistence	3,743.59	0.8224	1,871.78	0.4112
Cookhouse labor	1,172.35	0.2575	586.17	0.1288
Travel	94.23	0.0207	94.23	0.0207
Transportation	2,272.30	0.4992	1,136.15	0.2496
Equipment	420.42	0.0924	315.30	0.0693
Chemical materials	0.00	0.0000	1,593.20	0.3500
Total	$27,920.50	$6.1336	$18.771.37	$4.1238

but that consumed by all other personnel would be only one third as much during injection because they would be in camp only one third of the time. The cost of "Transportation" is decreased because packers, truck drivers, stock, and trucks are used only one third of the time, but extra men and tentage must be hauled. Under these circumstances it is felt that a charge of three fourths of the expenditures under "Equipment", one half of those under "Subsistence", and one half of those under "Transportation" is a conservative estimate of the cost reduction as a result of chemical treatment. One factor which has not been considered is the saving accruing because of the fact that chemical treatment can be applied at a season of the year when inclement weather does not cause any lost time. In general, therefore, it may be said that the cost of chemical treatment would be approximately two thirds of the cost for burning or peeling the infested logs. Economically, then, this method is decidedly superior to present control methods in western white pine.

The question still remains as to which of the two methods is more efficient in destroying broods of the mountain pine beetle. Chemical injection of trees by present methods is approximately from 95 to 99 per cent efficient. In the other method it is known that in certain cases portions of unburned bark remain after the burning, and that when burning can no longer be attempted in the woods because of fire hazard, peeling is not so efficient as either of the other two methods because the adult beetles are not destroyed. Furthermore, those trees in which the mortality following chemical treatment is not high are mostly trees which have been infested for some time, and these usually contain high percentages of beneficial insects. An attempt has been made to save these insects during control work by not treating such trees. Chemical treatment, however, saves them automatically, because parasites and predators are not destroyed by the poison except in the few cases in which they have not completed their feeding.

It is also to be noted that this method eliminates the use of fire, which always becomes a menace near the end of spring control work when the forests become rather dry. Chemical treatment can also be applied early in the fall before the weather becomes bad, and thus the factor of inclement weather, usually encountered during spring and fall control work, is eliminated. The standing snags that remain after chemical treatment constitute one disadvantage of this control method which has not been eliminated, although some compensation may be had if it is possible to preserve these snags by the chemicals in such a state that they can be harvested several years later.

Crew Organization and Equipment

It has been found that, depending upon the type of infestation, either a 2-man or a 5-man treating crew is the most feasible one to use. In areas where the trees are scattered the 2-man crew works better, while the 5-man crew is better where trees are grouped. In the 5-man organization 4 men work in pairs as usual, while the fifth man mixes the poison and carries the water.

Each 2-man crew should be provided with the following equipment which, excepting pack frames and water cans, should be doubled for a 5-man crew:

Saw.—In preparing the tree it has been found that an ordinary docking saw with a fairly coarse set works best for cutting the saw kerf.

Chisel.—In this work a 2-inch wood chisel is very handy for peeling the bark and scraping the wood surface. It is advantageous to replace the wooden handle of the chisel with a short piece of drill steel or metal pipe to give weight and extra length.

Collar Material.—The best collar material found to date is an inexpensive grade of knitted rubber sheeting. It is cheap, is a standard product which can be obtained at all times, and has sufficient elasticity to stretch with the weight of the solution. This material is purchased in bolts 1 yard in width, and by cutting the bolt in three pieces a roll of collar material 1 foot wide is secured.

Tin Strips.—The tin strips used to date are made from "1 x furnace tin" ½ inch wide and 2 feet long. Practically any sheet metal near 30 gauge in thickness will probably serve the purpose. It is also advisable to have the tin in 1-foot lengths in order to eliminate the need for cutting.

Nails.—Shingle nails have been used most successfully in fastening the tin. A large-headed nail similar to a bill poster's tack was tested in an attempt to eliminate the tin, but was not satisfactory.

Canvas Bag.—Two canvas bags 1 foot long and 2 inches square suspended from the belt facilitate transportation of the tin strips through the woods and keep them where they can be reached easily by the worker.

Pack Frame and Water Can.—A Nelson pack frame to which is attached a 5-gallon water can is desirable for transporting water in which the poison is to be dissolved.

Hammers.—Each man should be supplied with a hammer. A very cheap, light hammer is all that is necessary for this work.

Mixing Bucket.—Because of the necessity of mixing the poison in a noncorrosive container, a cheap wooden bucket was used during past projects and found satisfactory. For dosages of less than 1 pound of copper sulphate, a 1-gallon container is all that is necessary.

Knife.—A knife is necessary for cutting the collar material the proper length for each tree. In all probability all men employed on these projects will possess a jacknife, but if not the wood chisel will serve the purpose.

Poison.—The amount of poison carried by each 2-man crew depends upon the size of the dosages that are being injected. Past work has shown that a dosage of 8 ounces of copper sulphate dissolved in 3 quarts of water yields successful results in western white pine.

Conclusions

1. Western white pine trees infested with the mountain pine beetle can be injected with toxic solutions which, under certain conditions, will kill the bark beetle broods beneath the bark. The average mortality, when an effective poison and an approved method of injection are used, is over 90 per cent.

2. The saw-kerf rubberized-cloth collar method of injection has been found the most feasible method tested to date in western white pine.

3. Powdered copper sulphate ($CuSO_4 \cdot 5H_2O$) is the most effective poison tested to date.

4. The distribution of the poison and resultant mortality are apparently governed by the development of the blue-stain fungus. Blue-stain development, in turn, is dependent upon the time elapsing between attack by the beetles and the injection of the poison, the density of the wood, and perhaps other factors such as the moisture content of the wood, the temperature, and the intensity of infection.

5. The successful introduction of chemicals into trees is limited to those in which the attack is not over 90 days old. This necessarily limits the time of injection to the late summer and early fall.

6. Injection of chemicals into trees is a more practicable means of controlling bark beetles in western white pine stands than any method used at the present time.