The White Pine Weevil and Its Control by the Application of Concentrated Sprays

S. F. Potts, A. C. Cline, and H. L. McIntyre
U. S. Department of Agriculture, Bureau of Entomology and Plant Quarantine; Harvard Forest, Harvard University; and *New York State Department of Conservation*

That the white pine weevil causes serious damage to white pine is not news; that the weevil can be controlled effectively through the application of a poison spray which kills the female before eggs are laid is welcome news to foresters. Details of the treatment are presented in the following article.

THE white pine weevil (*Pissodes strobi* (Peck)) is one of the most destructive forest insect pests in the Northeast. By causing forked and crooked boles, extreme limbiness, and weaknesses in the wood itself, it has greatly reduced the usefulness and value of the injured white pine for all the more exacting needs of the lumber and building trades. This has been one of the principal factors responsible for the declining interest in the production of timber as a private enterprise in the Northeast. Some years ago many land owners set out white pine plantations on old fields and pastures, thinking them to be profitable investments, only to find later that their plantations were little more than rows of bushes. According to Reynolds,[1] hundreds of such plantations represent investments, including cost of trees, planting, maintenance, interest, and taxes, of from $50 to $100 per acre.

It is small wonder that entomologists and foresters in the Northeast have made this insect one of their principal subjects of study for many years past. A great deal has been learned about the life history and habits of the weevil which will be helpful in growing better-quality white pine in the future; but there remains the urgent question of how to minimize weevil attack in those plantations already established under conditions favorable for the weevil but not beyond the point in age when it is too late to save the butt log, the most valuable part of the tree.

Obviously, the best means of controlling this insect pest is that which prevents attack from taking place, rather than that which attempts to correct the form of the tree after the damage has been done. Even though such a treatment as the yearly pruning and destroying of infested leaders may serve to reduce the weevil population, there is, none the less, a loss of quality in those trees that are attacked, not to mention the costliness of such control measures.

In open-grown stands the most promising means of preventing the white pine leader from being attacked is through the application of a poison spray which kills the female weevil before any eggs are laid. In this paper the authors give the results obtained by applying a new type of spray to a number of white pine plantations growing under different conditions in the Northeast.

Life History and Habits of the White Pine Weevil in Relation to Control

The adult weevils hibernate in the litter and duff of the forest floor, usually beneath the tree from which they emerged earlier in the season. They come out of hibernation in the Northeast during the latter part of April and the first part of May, depending on the weather and the degree of swelling of the buds. After feeding for a few days on the buds and bark of the leaders the female weevils begin to lay their eggs.[2] The eggs are deposited in small excavations or puctures made in the bark, beginning just below the terminal buds, and they usually hatch in from 1 to 2 weeks. The larvae feed downward in the cambium layer, in a number of burrows that practically girdle the shoot. This causes the death of the leader and deformation of the tree. They pupate in the pith and wood of the dying leader. The weevils, after transforming from pupae to adults late in the summer, emerge and feed at intervals on the buds, leaders, and branches until fall, when they enter hibernation. This fall feeding by the new generation usually does not cause serious damage.

A number of species of conifers are attacked,

[1] Cline, A. C., and H. J. MacAloney. A method of reclaiming severely weeviled white pine plantations. Mass. Forestry Assoc. Bull. No. 152, pp. 1-12, illus. 1931.

[2] MacAloney, Harvey J. The white pine weevil (*Pissodes strobi* Peck)—its biology and control. N. Y. State College of Forestry Bull., Vol. III, No. 1 (Tech. Pub. No. 28), pp. 1-87, illus. 1930.

but white pine and Norway spruce are the most favored hosts. In general, weevil attack begins when the trees are about 5 years old, or 3 feet in height. The percentage of trees attacked per season increases yearly from then on until the trees are 15 to 20 feet high. After they reach approximately 25 feet in height, the percentage gradually decreases. Therefore it is particularly important to protect trees between approximately 5 and 20 years of age, because of the damage which otherwise would be done to the butt logs.

Review of Other Control Measures

SILVICULTURAL CONTROL

Growing white pine in high densities.—Straight, small-knotted trees may be produced despite weevil attack by growing white pine at such close spacings that it is impossible for the weeviled trees to become bushy. Under such conditions attacked trees are forced either to straighten quickly or to fall behind and become overtopped. Side pressure is so great that forks seldom form and crooks are necessarily slight. But these high densities, of at least 2,500 trees per acre, are so expensive to bring about, except through natural reproduction under favorable conditions, that there is no hope of making a profit on the investment.

Growing white pine under partial suppression.—It has frequently been observed that very slim leaders, such as might be found in suppressed trees, are not attractive to the female weevils as a place for laying eggs. Advantage may be taken of this fact to grow weevil-free trees which are also straight and small-knotted—the kind that eventually will produce very high-grade lumber. This method of control, however, requires not only the presence of an overhead canopy, to provide the necessary suppression, but also skillful handling by a forester.

Under natural conditions in the virgin forests white pine generally was obliged to compete with faster-growing or older trees. These conditions of partial suppression explain in a large degree the fine quality and form which is so commonly associated with old-growth pine. This natural way of producing high quality eventually will become the preferred method where pine is grown in mixtures, especially with hardwoods. At present, however, we are concerned chiefly with the thousands of acres of pure, even-aged pine plantations in which the trees have been free from suppression.

DIRECT CONTROL METHODS

Past attempts to control the weevil by direct methods included the following: (1) Collecting the adult weevils by hand at frequent intervals during the spring, (2) enclosing the leaders in cellophane bags early in the spring before the adults have emerged, (3) pruning and destroying infested leaders, and (4) the application of ordinary sprays containing repellents and stomach poisons. While these treatments have proved to be of some value, they have failed to meet the need for an efficient and inexpensive direct control method.

Since the beginning of Civilian Conservation Corps activities the method most extensively used to reduce the weevil population has been the removal and burning of the infested portion of the top of the tree before the weevils have emerged. As an additional treatment, to prevent forking, all but the most vigorous branch of the uppermost living whorl may be cut off. This method of treatment is expensive and usually does not effect a high degree of control.

Spraying the leaders with ordinary spray concentrations of repellents to prevent attack has been found to be ineffective as well as costly, although it is theoretically preferable to methods of control applied to the leader after it has become infested. Ineffective control was due to the composition of the ordinary spray material and the manner in which it was applied.

Reclamation Treatments

Cline and MacAloney[3] developed a method of improving, or reclaiming, severely weeviled white pine plantations by favoring and freeing enough of the least damaged trees to form the final stand—approximately 150 to 200 per acre. Such trees were found in the overtopped or nearly overtopped classes—in other words, under conditions of partial suppression. If attacked, they tend to straighten, for they have no opportunity to spread laterally and the only available growing space is directly above. The dominant trees, on the other hand, with their fat leaders extending into the full sunlight, are attacked repeatedly and develop numerous forks and crooks. By girdling these dominant "scrubs" Cline and MacAloney were able to stimulate and bring through enough fairly well-formed codominants and intermediates to form a well-stocked stand of trees having good butt logs.

[3]See footnote 1.

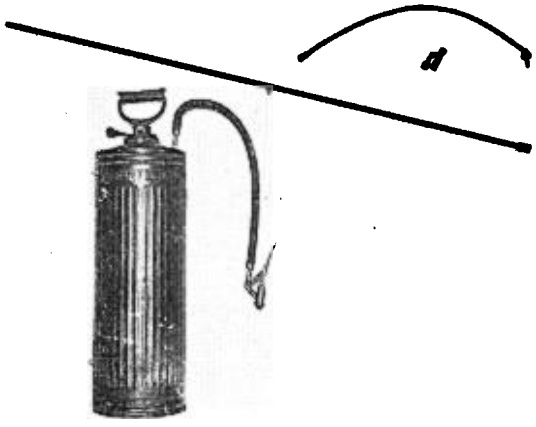

Fig. 1.—A compressed-air sprayer, with one 4-foot length of ¼-inch iron pipe and a 2-foot brass pipe with nozzle attached. The detached vermorel nozzle was used in the experiments of 1938.

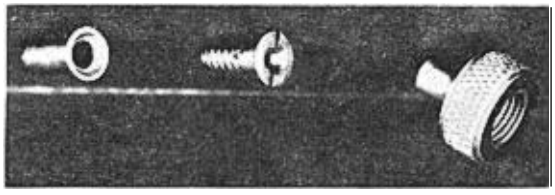

Fig. 3.—Special nozzle disassembled, consisting of a threaded holder, modified brass wood screw, and hollow-aperture shell.

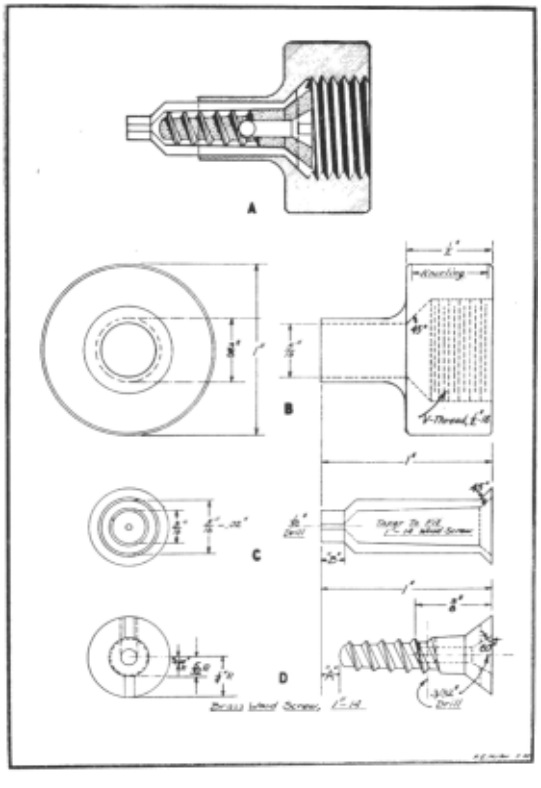

Fig. 2.—Details of construction of nozzle shown in Figure 3. *A*, Complete assembly; *B*, outer, knurled holder; *C*, hollow aperture shell; *D*, modified wood-screw.

Fig. 4.—Applying concentrated spray to the leader of a 12-foot white pine by use of a knapsack compressed-air sprayer, equipped with 4-foot hose and extension rod. Extension rods of different length may be used for treating trees of different heights.

The weakness of this sort of treatment is that the strongest trees, the dominants, are sacrificed in favor of less vigorous individuals, thus lengthening the period of time required to grow a crop of timber. Furthermore, the dead trees are unsightly and may add to the fire hazard.

Discussion of the Present Experiments

From 1937 to 1940 laboratory and small field tests of toxicity were made at New Haven, Conn., while at Keene, N. H., in cooperation with the Yale School of Forestry, at Petersham, Mass., with the Harvard Forest, and at Norwich, N. Y., with the New York State Department of Conservation, field tests were combined with a study of population and habits of the weevil in relation to control.

Laboratory and small-scale field tests were made with 13 different insecticides. The insecticides most toxic to the weevil were calcium arsenate, basic copper arsenate, acid lead arsenate, and cryolite. Calcium arsenate is the cheapest of these materials but has not had sufficient testing in the field to warrant its recommendation.

Tests made in 1938.—Two 1-acre plots were treated on May 3 and 4 in the Yale Forest, at Keene. The trees were 13 years old, from 6 to 12 feet high, and averaged 1,250 per acre, having a spacing of approximately 6 by 6 feet. One thousand similar trees bordering on the two treated plots were left unsprayed to serve as a check.

In Plot 1 a formula consisting of 1 part (by weight) of lead arsenate, 10 parts of water, 0.04 part of Aresket (spreader), and 0.4 part of fish oil was used. In plot 2 the formula was the same except that the lead arsenate concentration was half that used for plot 1. The application was made to the leaders by means of an ordinary compressed-air sprayer (Fig. 1) to which was attached a 6-foot extension rod and vermorel nozzle. Immediately back of the nozzle the extension rod was bowed in such a way as to direct the spray down onto the leader.

Twelve gallons of concentrate was applied to each plot. This was 10 and 5 pounds of lead arsenate, respectively, on plots 1 and 2. Although a heavy, fairly even coverage was obtained, it was estimated that only about 15 percent of the spray applied was deposited on the leaders. This wastage was due (1) to the fact that the spray was applied in the form of a hollow cone, (2) to insufficient atomization, and (3) to the high rate of delivery of spray by the conventional-type nozzzle. Seven man-hours were required to treat the 2 acres. In plot 1 98 percent protection of leaders was obtained, and in plot 2 96 percent, as found by comparing the number of infested leaders per 1,000 sprayed trees with the number of infested leaders per 1,000 unsprayed trees. In neither sprayed plot could live adult weevils be found 10 days after the application. Therefore, failure to obtain complete protection is believed to have been due to the fact that eggs had been deposited in some of the leaders before the application was made. Normally egg laying does not begin in this region until about May 5, but the year 1938 had one of the most advanced spring seasons recorded by the Weather Bureau.

The efficiency of a conventional 12½-gallon wheelbarrow sprayer for applying the above mixture was tried. In the use of such a sprayer, if the side branches do not overlap, the machine can be rolled down the rows, and if a 25-foot hose is attached, three rows can be conveniently sprayed on each side of the machine. Two men would be required to operate this unit. But if the branches are interlaced, the wheelbarrow unit cannot be used unless sufficient hose is provided to allow the nozzleman to go to the farthermost part of the stand. Such an operation would require three or four men.

Tests made in 1939.—A 1-acre plot and two plots of approximately 2 acres each were treated with the concentrated spray at Petersham between April 25 and May 2. The spray was applied by means of a compressed-air sprayer (Fig. 1), and a special nozzle (Figs. 2 and 3) was used. This nozzle gave a narrower solid-spray cone and a more finely atomized spray than the one used in 1938 and therefore gave better coverage and wasted less material. For this reason 5 gallons per acre was found sufficient. Furthermore, the solid-cone type of spray is much more efficient for white pine weevil control than the more conventional hollow-cone spray, which has a tendency to miss part of the leader and top whorl of shoots in the center of the spray cone.

In one of the 2-acre plots there were 1,280 8- to 9-year-old white pines per acre, averaging about 4 feet in height. The spray formula used consisted (by weight) of 1 part of lead arsenate, 10 parts of water, 0.03 part of sodium lauryl

sulfate (spreader), and 0.3 part of fish oil.[4] In an untreated portion of this stand 8.1 percent of the trees were attacked in the current season, whereas only 1 tree was attacked in the treated area. This represented over 99 percent control. The spray application required 6 man-hours' labor, and the total cost of treatment was $2 per acre.

Tests made near Norwich, N. Y., in 1940.— Approximately 50 acres of white pine were treated with concentrated spray during April in the vicinity of Norwich, N. Y. Suitable check trees were distributed throughout the treated areas. The trees in the different stands ranged from 3 to 14 feet in height. Except in a few cases when the spreader was omitted, the spray formula was 12½ pounds of lead arsenate, 54 fluid ounces of linseed oil, and 18 fluid ounces of 40-percent Aresket solution (spreader) to 15 gallons of water. This gave 15¾ gallons of final mixture. It was applied with knapsack compressed-air sprayers (Fig. 4) equipped with the nozzle used in the experiments of 1939. This nozzle is all brass and a plan of its three parts is shown in Figure 2. There is an outer knurled holder (B), which keeps the other two parts (C and D) in place when the assembled nozzle (A) is screwed onto an extension rod. The innermost part (D) is a wood-screw modified by having the tip filed off and a 1/16-inch hole drilled from the head to meet an intersecting hole drilled into the side of the screw at the base of the threads. This screw fits snugly into the other part (C), which is a hollow shell with a 0.03- to 0.04-inch aperture in the smaller end. The larger end has a beveled lip which receives the screw head and in turn fits into a corresponding bevel in the holder (B). A photograph of these three parts is shown in Figure 3. This nozzle is not on the market but can be constructed for about $1. Nozzles are obtainable on the market[5] which are nearly as satisfactory as the nozzle shown in Figures 2 and 3.

When trees have already been heavily attacked, or if leaders previously attacked have been pruned, as was the case in most of these stands, considerably more labor and material are required than for trees that have not been attacked. This is due to the necessity of treating all shoots of the top whorl of pruned or attacked trees, whereas only the leader of unattacked trees requires treatment.

An average of 96 percent reduction in the number of attacked trees was obtained by the treatment. This represents a total effective weevil mortality much greater than 96 percent, because there is apparently a high mortality of new adults as a result of summer and fall feeding on shoots and branches poisoned by the spring application. It is also possible that the number of weevils that issue from attacked poisoned leaders is less than the number that issue from attacked unpoisoned leaders.

The addition of a spreading agent made no noticeable different in control. Other tests, however have indicated that the spreading agent increases atomization and spreading, thus permitting adequate coverage with a minimum quantity of spray.

Some Points to be Considered in the Application of the Spray

The spray mixtures may be either prepared in the field or carried to the field in wide-mouth, covered containers. Care must be taken to avoid clogging of the nozzle. When the spray mixture is put into the spray tank it should be strained through a 40-mesh screen. All utensils and the sprayer should be kept free of dirt and trash. When spraying is discontinued, as at the end of each day, the spray tank should be rinsed out and the nozzle cleaned.

When materials are mixed, the spreader should be added to the water first, followed in order by the lead arsenate and the adhesive oil. It is necessary for all other ingredients to be thoroughly mixed before the oil is added. One or more 5-, 10-, or 15-gallon galvanized tubs served satisfactorily as mixing containers. When the sprayers are being filled it is essential that the mixture be kept stirred up from the bottom of the container. The quantities of different materials for making different volumes of the mixture are given in Table 1.

The cost of materials can be kept to a minimum by using fish oil instead of linseed oil, and by purchasing materials at wholesale prices insofar as possible.

Complete control requires that the buds and bark of all leaders be thoroughly covered with spray. If the leader has been killed or broken

[4]Linseed oil, corn oil, soybean oil, or cottonseed oil can be substituted for fish oil. In preparing the mixtures do not add oil until after all the other ingredients have been thoroughly mixed.

[5]Nozzle 1-S (brass), with ¼-inch female pipe connection, manufactured by Spray Engineering Company, 114 Central Street, Somerville, Mass., has been found to be satisfactory. Best results are obtained when the strainer is removed from this nozzle.

off, at least the leading shoots of the top whorl should be similarly covered. Within certain limits, weevils may select unsprayed spots on a poorly covered leader as a place to insert their snouts; but they have never been observed leaving a leader which was well sprayed with lead arsenate in search of unsprayed leaders. They obtain much, if not most, of their food from beneath the surface of the bark by inserting their snouts (0.2 to 0.3 milimeter diameter) to a depth of 0.4 to 0.7 millimeter. It naturally follows that the poison consumed when such a small hole is made would be insufficient to kill the weevil unless the leader was well coated.

The application should be made late in March or during April. (Further tests will be made to determine whether late summer or fall applications are effective.) Ordinarily the operator may treat two rows of trees while walking between them. In cases of dense, mixed growth with irregularly spaced pines, however, guide strings located about 25 feet apart will assist the operator in making sure of complete coverage of the stand, since he sprays by "lanes" bounded by the strings. It is not necessary that more than one or two such lanes be laid out ahead of the operator at any one time.

Observations made thus far indicate that the rate of reinfestation after a spray application is relatively slow, and that yearly treatments will not be necessary. The rate of reinfestation will be greatest in small areas that border on large, heavily infested white pine stands. It will be minimized in large, isolated sprayed areas.

TABLE 1.—QUANTITIES OF INGREDIENTS FOR MAKING DIFFERENT VOLUMES OF THE FINAL MIXTURE OF CONCENTRATED SPRAY[1]

Gallons of final mitxure	Water (by volume)	Lead arsenate (by weight)	Oil[2] (by volume)
1	7½ pts.	13⅓ ozs.	3⅓ ozs.
1¼	9½ pts.	1 lb.	4 ozs.
5	4¾ gals.	4 lbs., 3 ozs.	1 pt., ⅔ oz.
6¼	5¾ gals.	5 lbs.	1 pt., 4 ozs.
25	23¾ gals.	20 lbs., 13 ozs.	5 pts., 3 ozs.
31¼	28½ gals.	25 lbs.	3 qts., 4 ozs.

[1]In case a spreading agent is used, 0.02 pound of the dry form or 0.05 pound of 40-percent water solution of the spreader should be added per pound of lead arsenate. Aresket, Ultrawet, sodium lauryl sulfate, and Santomerse D are suitable spreading agents.

[2]Fish oil, linseed oil, corn oil, and soybean oil are efficient adhesives when used at the rate of 4 ounces of oil per pound of lead arsenate.

Treatment should begin as soon as the trees are large enough to be attractive to the weevil, usually when they are about 6 years old. They should be kept protected as long as the advantages of keeping a straight bole outweigh the expense of preventing weevil attack.

At this stage of its development this method affords protection primarily to the first, or butt log, since trees taller than 16 feet cannot be easily reached from the ground with the present equipment.

The method has the following advantages over certain other control methods aimed at producing straight butt logs: (1) It prevents attack by weevils, thus permitting normal growth in the tree and avoiding loss in arrested height growth and defects caused by crooks and forks in the bole and in twisted grain and compression wood; (2) it permits using the thriftiest trees (the dominants) in forming the main crop, thus shortening the rotation as compared with "reclamation" treatments; (3) it permits the use of wider spacings in plantations than in all postdamage methods of control, thus minimizing the cost of plantation establishment, and (4) it costs less per acre than any other methods that compare with it in effectiveness.

SUMMARY

The application of concentrated spray to several plantations, totaling about 65 acres, of 8-year- to 13- year-old white pines gave excellent protection against the white pine weevil. An effective mixture consisted of the following materials by weight: Lead arsenate 1 part, water 10 parts, adhesive oil 0.3 part, and with or without 0.02 to 0.03 part of spreader. The addition of the spreader did not materially affect the degree of control.

The method consists of applying approximately 5 gallons of mixture per acre to the white pine leaders late in March or during April by means of a compressed-air sprayer to which is attached an extension rod equipped with a solid-cone type of nozzle made for applying concentrated spray. Extension rods of suitable size and length were used for spraying trees up to 16 feet in height. Stands may be treated at the rate of about 2 acres per day per man at a total cost of $2 per acre. Undoubtedly more than one treatment will be needed throughout the life of of the stand, depending on the extent of reinfestation.