THESIS

CHEMICAL ERADICATION OF UNDESIRABLE PLANTS

By

WALDO PETTERTON

School of Forestry
Oregon State College

April 1934
CHEMICAL ERADICATION OF UNDESIRABLE PLANTS

INTRODUCTION

As foresters we are often called upon to kill trees and bushes as well as to grow them. Such trees and bushes as will be treated in this paper as inferior plants and which we find it profitable to eliminate may in a general way of speaking be called weeds in the forester's field of industry.

Much investigative work has been done in the chemical eradication of herbaceous plants and reports of such work can be very usefully adapted to the eradication of higher plants since they show the action of the chemical on the plant, however, this discussion will be limited to the elimination of woody plants by the use of chemicals.

NEED FOR THIS WORK

The practice of eliminating trees and bushes finds a great number of practical uses for the forester as well as in many other occupations. Foremost among these and also a very local problem is the eradication of poison oak along walks and roadsides. Others are the thinning of over-dense oak thickets, getting rid of clumps of thornapple, maple, or hazel nut bushes from pastures, ribes eradication, and other similar problems. Power lines and railroad companies are interested in keeping their right-of-ways through forests free of sprouts.

In the field of silviculture, efficient chemical eradication of trees and bushes would serve many purposes such as: (1) the prevention of sprouting of inferior species when
regeneration is through clear cutting, (2) the prevention of sprouting where growth of seedling origin is desired, (3) where inferior hardwoods are eliminated in favor of coniferous growth, (4) the elimination of an understory of undesirable species which prevents the establishment of a desirable species, (5) the elimination of leftover unmerchantable trees of poor quality after a cutting, and (6) the elimination of volunteer growth on old field planting sites.

**PURPOSE OF THIS PAPER**

Among the many ways of eradication possible are girdling, felling, cutting, hand pulling, grubbing, burning, and chemical eradication. It is the purpose of this paper to summarize the methods of chemical eradication, thereby revealing the advantages to be gained by their use.

**METHODS OF APPLICATION**

**SPRAYING**

A large amount of work in the way of eradication by spraying has been done in the extermination of various species of Ribes in the "Inland Empire" by the Division of Blister Rust Control. Ribes eradication by methods of hand pulling and grubbing is very costly because the ribes are generally very abundant, certain species layer prolifically, and the task of removing broken off roots and stems of such plants requires much time and labor.

Some twenty-five chemicals have been tried in the attempt to find a cheap and effective chemical for the destruction of ribes. Sodium chlorate applied at the rate of three pounds dissolved in a gallon of water to an area of one square rod has given 100% kills. Atlacide, a mixture of sodium chlorate
and calcium chloride for the purpose of decreasing the inflammability, can be applied with a little heavier concentration giving very much the same results as sodium chlorate.

H. R. Offord of the Division of Blister Rust Control, has recently found the use of ammonium thiocyanate for the destruction of Ribes is even more satisfactory than sodium chlorate, the heretofore most effective chemical. Applied at the concentration of two and one-half pounds per gallon of water, five thousand pounds applied per acre gives 100\% kill and smaller amounts applied per acre gives correspondingly about 10\% higher kill than sodium chlorate with the same application. Ammonium thiocyanate is particularly economical because of its source from recovered waste liquors of gas-scrubbers cheaply filtered and because of its safety to man and animals. Contrasted to sodium chlorate it is not inflammable and it is particularly distasteful to stock.

Sodium chlorate and sodium arsenite have been proven most successful in the destruction of Poison oak (Rhus diversiloba) in the vicinity of Corvallis. My work with sodium chlorate and sodium arsenite in the spring of 1933 was approximately 80\% successful using one and one-half pounds of sodium chlorate to the gallon of water and mixing sodium arsenite a 5\% aqueous solution. My experiments in spraying poison oak showed quite definitely that sodium chlorate and sodium arsenite are the most successful sprays used here. Sprays of sodium arsenite and arsenic caustic mixture both gave good results. I am inclined to think that the arsenic content of these sprays is the determining factor of their killing power.
I believe the success of spraying Poison Oak depends on the ability to cover the entire leaf, stem, and ground surface with a quantity of spray, consequently the efficiency of the spreader is largely the limiting factor. I have used laundry soap with good results; others that have been used are resin, fish oil, calcium caseinate and glue.

Whether the spray is most effective when applied to the leafy portion of the plant or to the ground so that it will act on the roots is yet an unsettled question. Offord's investigations (5) show that the best kill is gotten when sprays are mixed so as to conform with the pH of the plant which is slightly acidic. He concludes that the spray is taken internally by the plant and that the spray will be taken farther into the plant before toxic action takes place if the pH of the plant and spray correspond somewhat.

E. R. Jackman (9) extension agronomist at Oregon State College, believes just as good results may be had by spraying the full quantity on the ground thereby killing the roots, resulting in the death of the plant. This will be further discussed in effect of chemicals on the plant.

**INOCULATIONS OR POISONS APPLIED INTERNALLY TO THE STEM**

Offord conducted some experiments on inoculating ribes with solutions of various chemicals. A small instrument much on the order of a doctor's hypodermic needle was built for the application process and results as far as killing goes were successful, however, work on this phase was soon dropped because of the impracticalness of this method of application.
C. Rumbold, working with chestnut in an attempt to inoculate to kill or check the chestnut blight (Endothia parasitica), reports that solutions containing heavy metals were more deadly than those containing alkali metals. Her experiments also showed that all trees treated with chromates were dead the year following treatment.

It can readily be seen that this method of treatment is most applicable to larger woody plants and trees, such as thinning overly dense oak stands, eradication of thornapple and other inferior hardwoods, and a substitute for release cuttings in favor of certain species.

Intensive study has been made by A. L. MacKinney and C. F. Korstian of the Appalachian Forest Experiment Station on felling, girdling, and poisoning as methods of eliminating undesirable trees from the forest. Under conditions of the experiment poisoning with sodium arsenite was found the cheapest and most effective method (11).

Results of time studies made in this work showed poisoning to be the least time-consuming operation. Graphs reproduced from the February 1932 issue of the Journal of Forestry represent some of the striking data of this experiment. Figure 1 shows the direct productive time required to fell, girdle, and poison unmerchantable hardwoods of different diameters.

Poisoning was more effective than girdling in killing the crowns of trees during the first year following treatment. The height of the point of treatment above the ground had no appreciable effect on the mortality of the crowns of girdled and poisoned trees. Figure 2 illustrates this data.
The sprouting ability of poisoned trees was decreased considerably. The average maximum height of sprouts and the average number of sprouts per tree was lowest for poisoned trees and for girdled and felled trees, respectively. This is illustrated in Figure 3.

![Figure 3.](image)

Less sprouting was shown by trees treated close to the ground where girdling and poisoning was used. Sprouting ability was not affected by the height of cutting in the case of felling.

From the above discussion the conclusion may be drawn that poisoning is the best combination of cheapness and effectiveness for killing the crowns and reducing the basal sprouting of undesirable trees in the forest stand. To be most ef-
Effective, application should be made close to the ground. Investigations have shown that applications of poison are most effective when applied to the outer portions of the tree in the vicinity of the cambium layer and the effectiveness of applications in auger-holes are limited by the size of the tree, the larger the tree the less effective. An effective instrument for the application of sodium arsenite in "frills" at the base of trees is described by J. A. Cope and J. N. Spaeth in the Journal of Forestry, May 1931, (12).
In treating thornapple with poison it was found that the item of labor was the greatest expense. Therefore, this instrument which permits one man to do the entire application job was devised.

The tool is approximately five feet long, the upper four-fifths is the reservoir for the poison while the lower one foot section is made into a cutting tool. The pipe is cut at the four-foot mark and a two-inch brass cylinder sweated into the lower end of the four-foot section. This cylinder has a one-half inch hole bored through its center and a valve fitted at each end and attached to a piece of one-eighth inch wire which passes through the reservoir and cap at the top end. The valves are so arranged that when the top one is closed the lower one is open. When the cutting part is inserted at the base of a tree the wire at the upper end is given a quick pull thereby opening the upper valve and closing the lower one. By releasing the wire the measured quantity, which is approximately one teaspoon, is allowed to pass out through the lower valve and into the frill made by the cutting edge. A coil spring just under the reservoir cap keeps the upper valve closed tightly so that the poison does not leak out. The cutting edge is made concave so as to fit the shape of the tree and is somewhat rounded so as to prevent the poison from running out of the frill.

GROUND APPLICATIONS

By ground applications it should be understood will cover applications in or on the surface of the ground. These two phases are usually divided but because of the similar action on the plant they will not be discussed separately.
If all uses of chemicals for the destruction of obnoxious plant growth took the agronomists' point of view, the solution to the problem of chemical eradication of inferior plants would lie in this method of application. They advocate that in order that a plant be killed by chemical, it must be so applied that it will come in contact with the roots. (9) Accordingly, if spraying is done, it is just as effective to spray the ground as it is to spray the tops. The use of powdered dry material is just about as effective as spraying but it is a little more difficult to get uniform coverage. It is found that concentrated sprays are not quite as effective as dilute sprays, due probably to the better distribution with dilute sprays. Quoting Mr. E. R. Jackman, extension agronomist of Oregon State College:

"Most of the killing effect takes place through the roots, so a dilute spray will be carried down to the roots to better advantage than a concentrated spray which may mostly adhere to the top. If there is an extremely heavy top growth, making it difficult to get any material upon the ground, then it will usually pay to cut off the top growth and remove it before spraying. This latter is contrary to most recommendations, but we believe it is sound doctrine." (9)

Considerable experimental work was done by competent men in the Extension Service of Oregon State College in 1931 on ground applications of sodium chlorate and Atlacide, trying out the idea of putting it out dry on top of the soil. The work of these experiments was done on weeds, however, I think that the results of chemical actions on weeds are comparable to the
actions the same chemical will have on woody plants, although larger doses would have to be applied and action of the chemical on the plant would be slower. It should be understood that ground applications are practical only with the smaller woody plants and shrubs such as poison oak, ribes, wild rose, brush, etc.

Plots were staked out on which the material was sprayed at various strengths. The results of all these plots showed that both in Eastern and Western Oregon, the material can be put on the ground with nearly as great effectiveness as it can be sprayed on the weeds. Furthermore, this method allows the sodium chlorate to be used with no fire hazard whatever, because a man can go out late in the fall or early in the spring and scatter sodium chlorate over an infested patch when there is no top growth there to cause fire. Sodium chlorate is relatively cheap and this, of course, will result in a material saving of money as compared with atracide and in some cases a considerable saving of time and equipment in comparison with spraying.

Quoting from the November 13, 1931, issue of Science(13):

"A three-year study of the herbicidal action of sodium chlorate in the botany department of the Iowa State College indicates that this compound may be more effective when applied to the roots rather than to the aerial portions of the plant, and suggests that under humid conditions the elimination of perennial plants by spraying chlorates is dependent upon a portion of the spray residue reaching the soil. By applying the chemical, either crystalline or in solution, directly to the moist soil it is possible to reduce the quantities applied, and if the top growth of the plants is removed before treating,
the principal fire hazard is eliminated. The apparently unchanged chlorate salt persists in the soil for a period varying with the conditions from a few weeks to two or more years. The herbicidal action consists of both a direct killing of the underground portions of the plants and slow killing of new sprouts which may be formed.

A proposed plan to treat areas infested with poison oak by scattering sodium chlorate and Atlacide is about to be put into effect along the trail south of the cabin on the Peavy Arboretum. Results of this project can be had from Professor T. J. Starker, Oregon State School of Forestry.

Sulphur dioxide, used to a large extent in the fumigation of dried fruit, has been tried by the Division of Blister Rust Control in ground applications to kill ribes. Eight pounds of liquid is put under a pressure of eighty to one hundred pounds in a cylinder and when released, would be given off as a gas. Holes were made in the ground near the crown of the ribes bush and a certain amount of gas injected. These varied in number and were made at different depths. The killing effect of this chemical was not very satisfactory, furthermore, the inconvenience of the cylinders in application caused this method to be discontinued.

Another chemical, ethylene oxide, chemically related to the ethylene chloride which has been found to hasten very effectively the ripening of fruits and vegetables, has recently been described by R. B. Harvey, of the University of Minnesota, as a poison for undesired plants, such as poison ivy and poison
oak. It acts quickly and surely and then clears out of the soil. Professor Harvey has tried the compound on large barberry bushes with much success. He found the charges of ethylene oxide dissolved in water sunk into holes pierced in the soil at the roots of the bushes caused the bushes to be dead in a few days. About one and one-half ounces of ethylene oxide diluted to a ten per cent solution of water was sufficient for a large bush.

No doubt many more chemicals than those mentioned here have been tried with more or less success. Sodium chloride, common table salt, is very effective when sprinkled on the ground around the plant, however, the excess cost has limited its use considerably. Practically all chemicals applied to the roots of a plant will have ill effects on the health of the plant.

**EFFECT OF CHEMICALS ON PLANTS**

As I have previously stated, the actual effect of the chemicals on plants has been a matter of controversy for some time. It does not seem to be a definitely proven fact whether the plant is killed by poison saturating the soil and killing the roots or if the poison is taken into the sap stream of the plant and carried through the entire plant system thereby killing the protoplasm of the living cells and as a result starving out the plant because there is not enough living protoplasm left to manufacture food. The agronomists believe that the complete killing effect of the spray is the result of the chemical seeping down through the ground and killing the roots. On the other hand, the theory has been advanced that the killing
effect of the spray is caused by the chemical being taken internally and circulated throughout the plant system. The Division of Blister Rust Control does probably more spraying for the purpose of killing woody plants than any other industry or department. Under H. R. Offord's able leadership the Division is following a policy of spraying both the tops and the ground. It is quite evident that there should be some killing effect of applying a poisonous chemical to the roots of a plant, also if it is true that if a plant will take a chemical in through its leaves and circulate it throughout its system there should be even a greater killing effect when the chemical is applied in the form of a spray on the leaves.

Very little investigative work has been done in an attempt to determine whether or not a liquid will be taken up by the leaves of a plant and entered into the sap stream. Ginsburg (14) has experimented with petroleum oils of various viscosities being colored by an oil-soluable dye, showing the rate of penetration of various oils into plant tissue. Apple, peach, and tomato plants were used for this purpose. He has found that oil penetrates readily through the epidermis covering the under surface of the leaf and very slowly or not at all through the epidermis covering the upper surface of the leaf. Every one of the oils penetrated in pure form into the tissue, but the rate of penetration was indirectly proportional to the viscosity of the oil. These observations suggest that oils penetrate into the leaf tissue primarily through the stomata, since the latter are mostly located on the under surface of the
apple leaf. Results similar to those described were also obtained with leaves of peach trees and tomato plants.

Joy (15) in writing his thesis on Sprays for Killing Poison Oak" in 1931, states clearly that the chemical is taken internally by the plant through the stomata of the leaves and gradually starves out the plant through the destruction of the protoplasm of the living cells. Both Dr. R. H. Robinson of the Agricultural Experiment Station and Dr. Atwood of the Plant Physiology department say that to their knowledge this fact has never been proved, so I am inclined to think this part of Joy's thesis is merely the statement of an idea.

I have been a firm believer in the theory that the chemical when applied as a spray to the leaves is taken internally through the stomata and circulated in the cell sap throughout the plant system. I can also see the logic of the agronomist who says the plant is killed by the toxic action of the chemical on the roots. I believe it is a combination of the two that makes for successful kills in chemical eradication of undesirable plants.

In my attempt to prove that chemicals are taken in through the leaves various methods were tried before any usable results were obtained. However, each failure suggests a different course of procedure until finally a repetition of the process showed a definite change in the pH reaction of the plant when the chemical solution was applied to the leaves.

A common carrot was allowed to grow and sprout leaves in a beaker of water. The pH reaction of leaves of carrots is about 4.7, in other words, it is decidedly acidic in reaction.
A few of the leaves of the growing carrot plant were dipped in a basic solution of sodium hydroxide (NaOH). They were tied in a hanging position so that none of the basic solution could run up the stem on the outside.

When wilting of the stem some three or four inches away from the part that was dipped in the solution became apparent a section approximately an inch in length was cut for testing. The section was placed in a clean beaker where it was crushed sufficiently so that its juice could mix with a few drops of water that were added. When a drop of phenolphthalein, an indicator for basic reactions, was added the mixture turned a
bright red color, showing that the reaction of the leaf had been changed from an acidic to a basic by means of the basic solution entering the stomata of the leaves and traveling up the stem. The reaction was also tested with litmus paper which turned blue when put in the juice of the crushed stem. By the time three of these tests were made all giving favorable results, the plant was noticed to become generally unhealthy. Side leaves that had not been given any application of the basic solution began to wilt. When these side leaves were tested and found to give a basic reaction, the only conclusion that could be drawn was that the chemical was taken up by the leaves and circulated throughout the plant system. When the plant was allowed to grow in clean water without any further application of the chemical it regained vigor and grew many new leaves to replace those removed in treatment. Poor results were obtained when soap was added as a spreader. Leaves of carrot are very succulent and the soap seemed to dry up the leaves before the chemical could be taken into the plant. The leaves were then tied in such a position that they were hanging down into the solution with no spreading agent added.

This experiment could have been performed on a quantitative basis, but my limited knowledge of chemistry prevented it, however, it is a definite qualitative proof. Dr. R. H. Robinson of the Agricultural Experiment Station, who is an expert on sprays of various natures, checked the results of the experiment and was unable to locate any errors in performance.
SOME FACTORS DETERMINING EFFECTIVENESS OF APPLICATION

Spraying should be applied in the season of the year that the plant is growing. The application is probably most effective if applied when the sun is shining brightly because the stomata at that time are open and the processes of respiration and transpiration are going on actively. Spraying done twenty-four hours before a rain is not effective and should be resprayed. In spraying a bush, complete coverage is necessary. Both sides of the leaves, the bark of young stems, and the ground should be carefully covered. According to Professor Hyslop of the Farm Crops department, spraying sodium arsenite in the middle of the summer on Poison Oak has given 100% kills. In the Division of Blister Rust Control spraying ribes is not started until well after the rainy season is over and is stopped the first part of September when active growth ceases.

Inoculations into the stem of plants as well as applications in the ground can be performed most effectively in the spring of the year before plant growth becomes active. Experiments show that inoculations are most successful when made close to the crown of the tree. They should be made in the sapwood as close to the cambium layer as possible. The effectiveness of applications in the heartwood are inversely proportional to the distance they are from the sapwood. Applications in the ground can be made at almost any time of the year and still bring results, however, applications made in late winter or early spring will probably give the most success.
If chemicals are scattered on the ground before the early spring rains are over, they will be washed into the ground where they can react immediately to prevent added root or sprout growth. Chemicals will remain in the ground from a month to two years, depending on the amount applied and the character of the soil. This becomes an important factor to the agriculturalist, however, it is of minor importance to the forester.

**CONCLUSION**

It has been the purpose of this paper to review the field of chemical eradication of inferior plants. With the growing need for better silvicultural management of forest land this type of eradication will tend to be substituted for other methods of hand eradication because it is cheaper and more successful method and can be applied on a larger scale. The Division of Blister Rust Control is adapting this means of eradication more and more in place of the hand-pulling method. Silvicultural plans of the Central Hardwood Region can be benefitted by weeding undesirable trees from the stand by chemical means. More scenic spots and winding pathways will be made available to picnickers and tourists by eradicating the obnoxious Poison Oak. Chemical eradication is the solution of these and many other similar problems.

The methods of eradication herein proposed will greatly facilitate the elimination of undesirable plants. Forest owners, forest managers and the public in general will be interested in increasing the utility of their forest either from a timber producing or recreational standpoint. It is believed that this discussion will show new possibilities in this field.
REFERENCES USED

(1) Use of Chemicals in Weed Eradication
    Washington State College Extension Circular No. 16, August, 1932

(2) Eradication of Perennial Weeds in Minnesota
    University of Minnesota Special Bulletin No. 140

(3) Eradicating Perennial Weeds with Chlorates
    University of Minnesota Extension Circular No. 32

(4) Sulphuric Acid as a Weed Spray
    Journal of Agricultural Research - June 1927

(5) Chemical Eradication of Ribes by H. R. Offord
    U. S. D. A. Technical Bulletin No. 240

(6) Eradicating Perennial Weeds with Chlorates
    University of Minnesota Special Bulletin No. 140

(7) Use of Ammonium Thyocyanate for the Destruction of
    Ribes by H. R. Offord
    Western Blister Rust News Letter, Vol. 8, August 1933

(8) The Use of Chlorates in Weed Eradication by D. C. Smith
    Farm Crops Department, Oregon State College

(9) Looseleaf Literature from Files of E. R. Jackman, Agronomist
    Farm Crops Department, Oregon State College

(10) Progress Report on Poison Oak Spray Project by
    Waldo Petterson - On file in Professor T. J. Starker's
    Office, Oregon State School of Forestry

(11) Felling, Girdling, and Poisoning Undesirable Trees
    in Forest Stands, by A. L. MacKinney & C. F. Korstian
    Journal of Forestry, February 1932

(12) The Killing of Trees with Sodium Arsenite By Cope & Spaeth
    Journal of Forestry, May 1931

(13) Herbicidal Action of Sodium Chlorate by
    Professors Loomis, Bissey and Smith
    Science, November 13, 1931

(14) Penetration of Petroleum Oils into Plant Tissue, by
    Joseph M. Ginsburg
    Journal of Agriculture Research, Sept. 1, 1931

(15) A Thesis on "Sprays for Killing Poison Oak" by Fred L. Joy
    On file in Professor T. J. Starker's Office,
    School of Forestry, Oregon State College