POISONING WESTERN HEMLOCK WITH SODIUM ARSENITE

by

William I. Stein

A Thesis

Presented to the Faculty

of the

School of Forestry

Oregon State College

In Partial Fulfillment

of the Requirements for the Degree

Bachelor of Forestry

June 1948

Approved:

[redacted]

Professor of Forestry

ACKNOWLEDGEMENT

Without the cooperation and aid of members of the staff of the Pacific Northwest Forest and Range Experiment Station this thesis would not have been written. Through their advice, help and suggestions I have obtained the necessary data and personal experience so that it is possible for me to report the results of poisoning Western hemlock with Sodium Arsenite.

I wish to thank Mr. Philip Briegleb, Director of Management Research, for permission to use the subject-material. To Mr. Leo Isaac, Silviculturist, is credited valuable background information, general help and suggestions. To Mr. W. E. Bullard, Director, Wind River Experimental Forest, and his assistant, Mr. Robert Steele, Forester, goes the credit for conducting the major portion of the experiment, compilation of much of the data, and the observations of the final results. For the pictures I am indebted to Mr. Steele and to Mr. Bob Ruth of the Cascade Head Experimental Forest. To all of them, my heartfelt thanks and gratitude.

TABLE OF CONTENTS

I. ACKNOWLEDGEMENT i

II. INTRODUCTION
- a. Historical Summary 1
- b. Test Objectives 3

III. PLOT LOCATION AND DESCRIPTION
- a. Location of Experimental Area 5
- b. Climate and Soil 6
- c. Stand Description and Condition 7

IV. EXPERIMENTAL TECHNIQUE
- a. General Planning 9
- b. Plot Layout 10
- c. Selection and Marking of Trees 12
- d. Poison and Its Application 13
- e. Crew Organization 15
- f. Miscellaneous Equipment 16

V. EXPERIMENTAL DATA
- a. General Information 16
- b. Terminology 17
- c. Spring Poisoning 18
- d. Summer Poisoning 18
- e. Fall Poisoning 22
- f. Winter Poisoning 22

VI. OBSERVED RESULTS
- a. Poison Effect on the Tree 25
- b. Tool Use 27
- c. Season of Year 30
- d. Spacing of Cuts 33
- e. Results on Douglas Fir 34

VII. CONCLUSIONS 34

VIII. SUMMARY 36

IX. APPENDIX 37

LIST OF TABLES

Table Number Page

1. Spring Poisoning 19
2. Summer Poisoning 20
3. Fall Poisoning 23
4. Winter Poisoning 24
5. Tool Effectiveness 29
6. Seasonal Effectiveness 29
7. Seasonal Effectiveness by Spacing 32
8. Spacing of Cuts 32

INTRODUCTION

Historical Summary

In the management of forests, one of the chief concerns of the forester has been to make improvements in the unmanaged stand. One of the recognized stand improvement measures has been the removal of cull trees which take up space and are an economic liability to the forest landowner. How to remove cull trees or reduce their negative effect on the rest of the stand is one of the forester's major problems. In the past, this problem has been solved by several methods. Each of these methods has been useful, but the search for still more practical and less costly ways continues.

Cull trees have been disposed of by harvesting them along with the desirable trees and making the better trees pay for the cost of removal. This is a quite general practice which is often economically feasible, but it is quite expensive and cannot be practiced under all circumstances. It has the advantage of aiding the closer utilization of all our timber resources though the economic burden is not desirable or always justified.

To eliminate the burden of harvesting the cull trees, other methods have been sought. One of the simplest of these is to leave the cull trees standing. Though this is practiced, it is recognized that little is accomplished as the trees not removed still take up space and use nutrients which could be much more profitably expended in the production of a new stand. Consequently, efforts have been directed toward leaving the tree and reducing or eliminating its influence on the remainder of the stand. Following this policy, methods have been sought where-by the tree could be killed but not be physically removed from the area. This has been accomplished by either of two methods: to cut the tree down and let it lie or to let it stand and girdle it. These methods have been proven satisfactory, but they are still quite costly.

Through continued experimentation, more economical methods of killing trees have been sought. It has been known for a long time that various compounds are toxic to plants. If some of these could be adapted to use as tree killers, a cheap and economical method of eliminating cull trees would be available. Working toward this goal, various poisoning experiments have been conducted throughout the United States. Using information obtained in previous experiments, a poisoning test was planned and conducted by the Pacific Northwest Forest and Range Experiment Station to determine the feasibility of eliminating cull Western hemlock trees by poisoning.

Test Objectives

From previous experiments it was known that Sodium Arsenite was one of the most effective tree poisons, but many factors and conditions governing its use and application were not known. When conducting this experiment to determine Sodium Arsenite poisoning effectiveness on Western hemlock, several of these unknown factors could also be observed and made a part of the experiment.

Although Sodium Arsenite is not a highly expensive chemical, its cost does materially affect the total cost of poisoning. Therefore, one test objective was to find out the minimum amount of poison necessary to kill a tree of any given diameter. This involved the number of places on the tree that it was necessary to inject the poison as well as the amount of poison to be applied at each location.

In previous experimentation, various methods of poison application had been tried with success dependent to some extent on local conditions and species. The method of application was partially governed by the form in which the poison was to be used, either liquid or crystalline. In this experiment the liquid form was to be used. The best way to apply liquid poison is by cutting holes into the tree trunk and pouring in the poison. These holes are made with various tools, probably the first one used being an ordinary brace and bit.

This hole-making method is slow, tedious, and costly. Other methods had been developed, most of them on the principle of using a tool in the same manner as an axe but with some kind of attachment which would cut a hole that would hold poison solution long enough for the tree to absorb it. Plans for this type of tool were obtained and the tool was constructed. By chance a mistake was made in construction so a variation of the original tool was produced, and thus entirely by accident another axe-like tool was made available for use. A factor to be tested then was the comparative efficiency in the operation and the poison application effectiveness of the original tool and its new variation.

From a knowledge of the physiological processes of the tree, there appeared to be an almost certain possibility that poisoning would be more effective at certain seasons of the year than at others. This factor was to be tested by poisoning some trees at each of the four seasons of the year. In addition to seasonal effect, the staying power of the poison could possibly be observed if it were applied in the season when the trees were dormant or almost so and the results were observed in the next growing season. Observation of the trees over a period of time might answer the question of whether the tree could recuperate if a complete kill was not obtained within a few weeks after the poison was applied. These specific factors mentioned and the search for general information were the objectives of the experiment.

PLOT LOCATION AND DESCRIPTION

Location of Experimental Area

The hemlock poison area is located in Skamania County of the State of Washington and is included in the Wind River District of the Columbia National Forest. It is an intregal part of the Wind River Experimental Forest which is managed and administered by personnel of the Pacific Northwest Forest and Range Experiment Station. The poisoned trees are located on approximately five acres of ground on the slope of Trout Creek Hill in the northwest quarter of the northeast quarter of Section 19, Township 4 North, Range 7 East, Willamette Meridian. It is possible to drive within one hundred yards or less of the poisoning area which lies on both sides of the Trout Creek Road about two and one-half miles West of the Hemlock Ranger Station and about three-fourths of a mile southwest of the western boundary of the Natural Area. The poison plot marker board is several hundred feet beyond the point where the upper branch of the Trout Creek Hill Trail begins.

The topographic location of the Wind River District is in the center of the Cascade Range. It is an area of hills and mountains that range in elevation from

2000 to 6000 feet or more. The poison plot is located at about 1500 feet elevation on the southeast side of Trout Creek Hill which has a gentle to moderate slope rising to an altitude of about 2000 feet. Within the plot boundaries the slope does not exceed 15 percent. A convergence of the slope from three sides forms a quite level bench which makes up the major area of the plot.

Climate and Soil

The climate of this sector is quite typical of that of the west slope of the Cascades in Oregon and Washington. Precipitation is heavy during the fall, winter, and spring with drought conditions existing during part of the summer. At most times of the year the weather does not become excessively cold, yet at the same time there exists a relatively short frost-free period and most nights are fairly cold. Wet snow during the winter causes heavy damage to trees occasionally. It is relatively hotter and colder than is should be for this given altitude and latitude as the Wind River Valley opens to the southeast and receives some of the extremes of heat and cold from the continental air masses originating to the East.

Site conditions for the plot and the immediate surrounding area are rated as Douglas-fir site III. The soil is a sandy loam varying in depth from very shallow to deep. It is very porous and often contains gravel or stone.

Stand Description and Condition

The stand is a mixed type, varying in classification between mature Douglas fir _(Pseudotsuga taxifolia)_ and Western hemlock _(Tsuga heterophylla)_. Mixed in with these two principle species are Western white pine _(Pinus monticola)_, Noble fir _(Abies procera)_, Pacific silver fir _(Abies amabilis)_, Grand fir _(Abies grandis)_, Western red cedar _(Thuja plicata)_, Pacific yew _(Taxus brevifolia)_, and various hardwoods including Pacific dogwood _(Cornus nuttalli)_, Red alder _(Alnus rubra)_, Vine maple _(Acer circinatum)_, Big-leaf maple _(Acer macrophyllum)_, and Hazelnut _(Corylus californica)_. Small areas of almost pure stands of Pacific silver fir can be found, especially at the higher elevations of Trout Creek Hill. At the present time, the stand is in a stage of decomposition with the over-mature Douglas fir fading out of the stand and being replaced mainly by Western hemlock and Pacific silver fir.

The openings which occur due to over-mature Douglas fir falling out are immediately taken over by groves of Vine maple. This troublesome species is also found scattered throughout most of the stand as an understory tree along with Pacific yew. Many bushes and plants are evident in the understory wherever the crown cover is not too dense; the most important of these being Red huckleberry (Vaccinium parvifolium), Blue huckleberry (Vaccinium membranaceum), and Rhododendron (Rhododendron macrophyllum).

Since the stand is undergoing rapid changes, no specific statement can be made about its condition. There are many over-mature Douglas fir trees that are fading out of the stand. In addition to this, some of the larger Western hemlock trees have been struck by lightning and have little value for commercial purposes. White pine blister rust (Cronartium ribicola) takes an unceasing toll of Western white pine reproduction and also a few of the older trees. This pine is not too numerous but is well-scattered throughout the stand. A few over-mature Pacific silver fir trees are in evidence, but the great majority of this species is of medium size or smaller. To the contrary, the few Noble fir trees present are almost all tall, smooth-boled, and mature. Although Grand fir is present, the stems are few and far between and are small in size. Mistletoe is to be found on Western hemlock and Pacific silver fir higher up on Trout Creek Hill, but is is not in evidence close to the poison plot.

There is little evidence of animal damage. A few cases of porcupine and bear damage on cedar trees can be found. Browsing signs are noticeable, but are not heavy enough to be a real damage factor.

EXPERIMENTAL TECHNIQUE

General Planning

The entire poisoning experiment was conducted as a small phase of the work to be accomplished by the Wind River staff of the Pacific Northwest Forest and Range Experiment Station during the summer season of 1947. As it required little time and a minimum of extensive planning, it was inserted into the work schedule whereever it could be fitted with a minimum of disruption to the major summer projects.

It was not considered necessary to test seasonal poison effectiveness at any particular day during that season. Therefore, poison application dates were arbitrarily chosen approximately three months apart. The poison was then applied on or near this date as it could be conveniently integrated into the regular work schedule. Consequently, seasonal dates vary somewhat, this being especially true in the fall when the poison was applied in a split operation approximately ten days apart. It is believed that there will be no difference in effect due to this ten day interval, but this assumption is not being tested.

Quite a number of trees were needed in order to test the factors which were to be observed. In order to keep this number to a minium, it was decided that it would be unnecessary to test for each factor at each season of the year. Therefore, the number of trees poisoned each season varied according to the factors which were being tested. It was planned to poison the largest group of trees in the summer which represented approximately the middle of the growing season. The number of trees necessary for the fall and winter tests was to be determined largely by the results obtained from the summer test.

In the original planning, the trees to be poisoned were all to be wolf trees or defective trees of the stand. It was soon discovered that in order to obtain the necessary diameter classes within an area small enough to be easily laid out and covered, it was necessary to include merchantable trees among those poisoned. This was permissible as the merchantable trees could be salvaged readily within a year or two by a logging operation which was to include the poison plot area.

Plot Layout

The layout of the various boundaries of the poison area was done by compass and pacing. The main purpose for establishing any boundaries being to provide a guide so that the tagged and poisoned trees could be readily found on future occasions during the next year or two. To accomplish this purpose a stake with a marker board has been set alongside the road just beyond the turn at which the upper branch of the Trout

Creek Hill Trail begins.

The group of trees poisoned for each season of the year was kept separate from those poisoned the preceding season with a few exceptions. It was not found possible to keep entirely separate those of the various seasons and still confine the entire poisoning operation to a small, compact area. Therefore, in order to find trees in the correct diameter classes, several trees in the summer poisoning group are located among those poisoned in the spring of the year. All trees poisoned in the spring and summer are located west of the road which at this particular point runs Southwest. The trees poisoned in the fall and winter are located on the opposite side of the road.

A rough boundary line was run around the part of the plot on the west side of the road, using a staff compass and pacing. Very light bark blazing was done to make the boundary at least slightly noticeable. On the east side of the road so few trees were required that no boundary line was laid out. There are several trees located just outside the plot boundaries on the west side. These were required to help fill some diameter classes which could not be filled due to the absence of that size tree inside the plot.

After the boundary line had been run around the plot, all trees that were poisoned were roughly plotted on a sketch map in order to give an approximate location of each tree as an aid in finding it at future inspection dates. Plotting was done by estimating distance from the nearest boundary and determining direction with a hand compass. The trees poisoned on the east side of the road were plotted according to estimated distances from the road.

Selection and Marking of Trees

For the purpose of this experiment, trees were classified into 5 inch diameter classes of 7"-12", 13"-18", 19"-24", 25"-30", and 31" and over. In the summer group, trees were only tallied by diameter classes, while for the other seasons of the year actual diameters were recorded. The trees were tagged with numbered aluminum tags in a consecutive series (P1, P2,....) which was continued the next season at the point where it stopped during the preceding season. As testing factors varied, the number of trees each season also varied so that 25 trees were poisoned in the spring (including 2 Douglas fir), 100 trees in the summer, 16 trees in the fall and 8 trees in the winter.

Since there were two tools to be tested for poison application effectiveness, paired trees for each diameter class were poisoned in the spring and summer. The results of these two seasons proved conclusively which tool was the better of the two and it was not necessary to use paired trees during the other two seasons.

Testing for the spacing of poison applications was done in every season of the year except winter. The spacing was varied for each season according to the results of the previous season. In the spring, spacing covered the whole range of classes from 1" to 18" at 1" intervals for each tool. The summer applications were spaced in a range from 2" to 12" with a 2" interval between spacing classes. Results by fall indicated that only a 6" spacing and a 12" spacing still needed to be tested.

Poison and its Application

The poison used in this experiment was Atlas "A" commercial weed killer, which is made by the Chipman Chemical Company. It is a solution of 4 pounds of Sodium Arsenite and 1 pound of Caustic Soda per 1 gallon of water. The active ingredients of this poison are: Sodium Arsenite - 40% (total arsenic, all water-soluable expressed as metallic arsenic - 24%), and inert ingredients not over 60%.

The poison was applied with two types of containers: an ordinary oil can with a long stem and an alemite gun. It was soon apparent that the oil can was the more practical tool to use even though it had to be refilled more often. The alemite gun delivered too much spray instead of a stream and also plugged up quite easily.

To replenish the supply of poison in the application tools, a gallon glass jug of poison was carried along with the other equipment.

The process of getting the poison to the cambium of the tree was accomplished through the use of the two types of plug-cutting tools. The term "plugcutter" adequately describes the function which the two converted axes performed. The process consisted of using the tools in the same manner as an axe, only instead of having the bit strike into the bark and wood, an attachment which had been welded onto the head of the axe would cut out a round plug of wood. The removal of this plug of wood which is about ½" in diameter and 1" to 2½" long is for the purpose of exposing the cambium and forming a hole into which the liquid poison could be poured. These plug-holes were cut into the tree trunk about 3' from the ground and formed an approximate circle around the tree. Spacing effectiveness testing consisted of locating these plug-holes at given distances around the trunk. The spacing and quality of holes depends on the skill of the man using the tool. So that the plug-holes would hold poison well, they were cut at an angle sloping down and in. This angle could not be made too steep or the cut would not be across the grain enough to sever the wood. After the tree had received the prescribed number of plug-holes, one of the poison containers was used to fill the hole with poison. As a general rule, only one filling of each hole was made. The tree absorbed the poison in the freshly cut holes very rapidly.

A detailed description of the plugcutters must be included in this discussion as they are quite unique and are not too well known. When preparing to conduct this experiment, the Pacific Northwest Experiment Station obtained plans of a similiar tool which had previously been used by the Southern Experiment Station. These plans were given to the shop in order to have a similiar tool made for this experiment. Through a mistake in making the tool, the plugcutting attachment was welded flush to the face and even with the sharp edge of a double-bitted axe instead of being mounted on the hammer side of a pole axe. In this manner, a new tool was created and since it looked practical, it was decided to test this new model as well as an original model. It is much easier to describe the tools with pictures than in words, so pictures of both tools are listed in the appendix.

Crew Organization

The regular crew for the hemlock poison operation consisted of three men, and the necessary duties were divided up among these three as equitably as was possible in order to complete the job rapidly. There were no rigid lines drawn as to the beginning or ending of each man's duties.

For the plot layout and tree tagging, one man did the tagging and measurement. The other ran the staff compass to determine boundary lines, while the third recorded measurements and plotted tree locations.

When applying the poison, two men used the plugcutters and each also carried and applied the poison. Again the third man acted as recorder and kept tract of the treatment which had been designated in advance for each tree. The work progressed rapidly and the division of duties was such that very little time was lost.

Miscellaneous Equipment

Most of the equipment has been mentioned in the discussion up to this point. Except for the plugcutters, it is equipment that any forestry enterprise has available and includes: Hammer, nails, tree tags, staff compass, tatum holder with tally sheets, maps, oil cans and a glass jug.

EXPERIMENTAL DATA

General Information

In the following tables are listed the individual trees, the treatment each received, and the observed results of later inspections. The double-bitted axe with the plugcutter was commonly referred to as the "notch and plug" tool and is listed in the tables as tool "A". The converted pole axe was simply referred to as the "plugcutter" and is listed in the tables as tool "B".

When the results were observed, a few words or short sentences were used to describe the condition of the tree. For lack of space, it is not possible or desirable to list these descriptions in the tables as they were originally used in the field. Given below is a standardized list of terminology which has been used in the tables and which should give the reader a description of the condition of each tree.

Terminology

1. Dead

No green branches or twigs are present. Much of the foliage has fallen and the rest of it has turned brown.

2. Almost dead

Only a few green limbs still remain. Most of the foliage has turned color and fallen. Those few green limbs remaining usually are present on the bottom of the tree.

3. Top dead

This classification indicates the top is dead, the middle usually is dying and the bottom of the tree appears relatively unaffected.

4. Dying

The tree has a general sickly appearance with the needles turning yellow and starting to fall. Scattered dead twigs and limbs can be seen, but no definite area of the tree appears more affected than any other part.

5. Dead twigs

Only scattered twigs are dead or dying.

It is presumed that these are caused by the poisoning but not enough dead material is present to prove conclusively that the poison has taken effect.

6. Alive

There is no evidence that the poison has had any effect.

Spring Poisoning

The trees poisoned in the spring of the year were not systematically selected according to diameter classes. Rather, an area was selected and 25 poor and defective trees in that area were poisoned. The two Douglas fir that were poisoned were also non-merchantable. Spacing varied from 1" to 18" by 1" interval classes and one-half of the paired trees were poisoned with each tool. The effect of poisoning was noticeable within several weeks on many of the trees and by the time of the summer poisoning several of the trees were already dead as can be observed in Table 1.

Summer Poisoning

The main poisoning effort was made in the summer season when all factors were being tested. Trees were listed by diameter classes and one-half of them were treated with each poisoning tool. Spacing was done by 2" interval classes from 2" to 10" inclusive for trees of each diameter class. Here again results were noticeable within a few weeks and the trees began to die quite rapidly. Listed in Table 2 in the fifth column is the observed condition for each tree as of the 15th of August

TABLE 1

Trees poisoned in the Spring on the 14th of March 1947

Tree No.	Diam. Inches	Tool Used	Plug Spacing	Observations 17/6/47	15/8/47	April 48
P1	32.9"	A	1"	Dead twigs	Dying	Dead
2	21.9	A	2	Dying	Almost dead	Dead
3	21.5	A	3	Dead	Dead	Dead
4	28.1	A	4	Dead twigs	Top dead	Almost dead
5	20.4	A	12	Dead twigs	Top dead	Almost dead
6	17.6	A	6	Almost dead	Almost dead	Almost dead
7	16.8	A	8	Dead twigs	Dying	Almost dead
8	35.4	A	10	Dead twigs	Top dead	Top dead
9 DF	32.5	A	12	Alive	Alive	Alive
10	30.4	A	14	Dead twigs	Top dead	Almost dead
11	39.7	A	16	Dead twigs	Top dead	Almost dead
12	17.5	A	18	Alive	Top dead	Top dead
13	8.5	B	20	Almost dead	Almost dead	Dead
14	38.1	B	16	Alive	Dying	Alive
15	12.6	B	18	Dying	Top dead	Top dead
16	24.2	B	3	Dead	Dead	Dead
17	15.0	B	6	Dying	Almost dead	Dead
18	8.2	B	8	Dead	Dead	Dead
19	21.8	B	2	Dead	Dead	Dead
20	34.9	B	10	Dying	Top dead	Top dead
21	33.4	B	1	Dead	Dead	Dead
22 DF	36.4	B	12	Alive	Alive	Alive
23	34.5	B	14	Alive	Top dead	Almost dead
24	30.4	B	4	Almost dead	Dead	Dead
25	25.8	B	8	Dead	Dead	Dead

DF - Douglas fir

TABLE 2

Trees poisoned in the Summer on the 17th of June 1947

Tree No.	Diam. Class	Tool Used	Plug Spacing	Observations 15/8/47	May 1948
P26	7-12"	A	2"	Dead	Dead
27	"	A	2	Almost dead	Dead
28	"	A	4	Dead	Dead
29	"	A	4	Dead	Dead
30	"	A	6	Dead	Dead
31	"	A	6	Dead	Dead
32	"	A	8	Almost dead	Dead
33	"	A	8	Top dead	Almost dead
34	"	A	10	Almost dead	Almost dead
35	"	A	10	Dead	Dead
36	13-18	A	2	Dead	Dead
37	"	A	2	Dead	Dead
38	"	A	4	Almost dead	Almost dead
39	"	A	4	Top dead	Almost dead
40	"	A	6	Almost dead	Dead
41	"	A	6	Almost dead	Dead
42	"	A	8	Top dead	Almost dead
43	"	A	8	Top dead	Almost dead
44	"	A	10	Top dead	Almost dead
45	"	A	10	Top dead	Top dead
46	19-24	A	2	Almost dead	Dead
47	"	A	2	Top dead	Dead
48	"	A	4	Almost dead	Top dead
49	"	A	4	Almost dead	Dead
50	"	A	6	Almost dead	Almost dead
51	"	A	6	Top dead	Almost dead
52	"	A	8	Top dead	Almost dead
53	"	A	8	Dying	Almost dead
54	"	A	10	Top dead	Top dead
55	"	A	10	Top dead	Top dead
56	25-30	A	2	Top dead	Almost dead
57	"	A	2	Almost dead	Dead
58	"	A	4	Dying	Almost dead
59	"	A	4	Almost dead	Dead
60	"	A	6	Top dead	Almost dead
61	"	A	6	Top dead	Almost dead
62	"	A	8	Top dead	Top dead
63	"	A	8	Top dead	Dying
64	"	A	10	Top dead	Almost dead
65	"	A	10	Dying	Dying
66	31 & up	A	2	Top dead	Almost dead
67	"	A	2	Dying	Top dead
68	"	A	4	Top dead	Almost dead
69	"	A	4	Dying	Almost dead
70	"	A	6	Dying	Almost dead
71	"	A	6	Dying	Dying
72	"	A	8	Top dead	Top dead
73	"	A	8	Top dead	Almost dead
74	"	A	10	Almost dead	Almost dead
75	"	A	10	Dying	Dying

Tree No.	Diam. Class	Tool Used	Plug Spacing	Observations 15/8/47	May 1948
P76	7-12"	B	2"	Dead	Dead
77	"	B	2	Dead	Dead
78	"	B	4	Dead	Dead
79	"	B	4	Almost dead	Dead
80	"	B	6	Almost dead	Dead
81	"	B	6	Almost dead	Dead
82	"	B	8	Top dead	Almost dead
83	"	B	8	Almost dead	Almost dead
84	"	B	10	Almost dead	Dead
85	"	B	10	Almost dead	Almost dead
86	13-18	B	2	Dead	Dead
87	"	B	2	Almost dead	Dead
88	"	B	4	Almost dead	Dead
89	"	B	4	Almost dead	Almost dead
90	"	B	6	Top dead	Top dead
91	"	B	6	Almost dead	Almost dead
92	"	B	8	Top dead	Dying
93	"	B	8	Top dead	Almost dead
94	"	B	10	Almost dead	Dead
95	"	B	10	Top dead	Almost dead
96	19-24	B	2	Almost dead	Dead
97	"	B	2	Dead	Dead
98	"	B	4	Almost dead	Almost dead
99	"	B	4	Top dead	Almost dead
100	"	B	6	Dead	Almost dead
101	"	B	6	Almost dead	Almost dead
102	"	B	8	Top dead	Top dead
103	"	B	8	Top dead	Almost dead
104	"	B	10	Top dead	Dying
105	"	B	10	Top dead	Top dead
106	25-30	B	2	Top dead	Dead
107	"	B	2	Almost dead	Almost dead
108	"	B	4	Almost dead	Almost dead
109	"	B	4	Top dead	Almost dead
110	"	B	6	Almost dead	Almost dead
111	"	B	6	Almost dead	Almost dead
112	"	B	8	Top dead	Dying
113	"	B	8	Almost dead	Almost dead
114	"	B	10	Top dead	Dying
115	"	B	10	Top dead	Top dead
116	31 & up	B	2	Almost dead	Almost dead
117	"	B	2	Almost dead	Dead
118	"	B	4	Top dead	Almost dead
119	"	B	4	Top dead	Top dead
120	"	B	6	Almost dead	Almost dead
121	"	B	6	Almost dead	Almost dead
122	"	B	8	Almost dead	Top dead
123	"	B	8	Top dead	Almost dead
124	"	B	10	Top dead	Top dead
125	"	B	10	Top dead	Dying

when the fall poisoning was begun.

Fall Poisoning

The size of the fall poisoning test was determined by the results of the spring and summer tests. By that time it had become apparent that both tools were effective in performing the job well but because of handling ease the notch and plug tool was used for the sixteen trees that were poisoned. Only two spacings were used, 6" and 12", because the preliminary results showed little conclusive evidence that any particular spacing class gave the most satisfactory results. Therefore a wide and a relatively narrow spacing were contrasted. Trees were tabulated by diameter classes and by exact diameters as is shown in Table 3. Again some poison effect could be observed within a few weeks.

Winter Poisoning

The previous poisonings had tested all factors except the effect of poison in the winter season. Therefore only eight trees were poisoned in the winter on the 17th of November. These trees were selected according to their defectiveness without regard to diameter class and poisoned with the notch and plug tool. In the middle of January the trees were inspected and few if any positive effects of the poisoning could be seen (Table 4). This is in direct contrast to the results of the previous seasons which all showed definite effects when inspected an equivalent amount of time later. A tabula-

TABLE 3

Trees poisoned in the Fall on the 15th of September 1947

Tree No.	DBH Inches	DBH Class	Tool Used	Plug Spacing	Observations 17/11/47	Observations April '48
P126	13.1"	13-18"	A	6"	Almost dead	Almost dead
127	18.1	13-18	A	6	Top dead	Almost dead
128	21.4	19-24	A	6	Almost dead	Almost dead
129	20.1	19-24	A	6	Top dead	Almost dead
130	29.7	25-30	A	6	Top dead	Almost dead
131	30.3	25-30	A	6	Top dead	Top dead
132	41.3	31 &	A	6	Dying	Top dead
133	40.6	31 &	A	6	Dying	Dying
134	15.0	13-18	A	12	Dead	Dead
135	18.3	13-18	A	12	Top dead	Almost dead
136	22.0	19-24	A	12	Alive	(lost)
137	23.5	19-24	A	12	Dead twigs	Almost dead
138	29.7	25-30	A	12	Dead twigs	Top dead
139	28.2	25-30	A	12	Dying	Dying
140	44.5	31 &	A	12	Top dead	Top dead
141	31.1	31 &	A	12	Alive	Top dead

TABLE 4

Trees poisoned in the Winter on the 27th of November 1947

Tree No.	DBH Inches	Tool Used	Plug Spacing	Observations 14/1/48	April '48
P142	48.1"	A	6"	Dead twigs	Dying
143	40.9	A	6	Alive	Alive
144	13.0	A	6	Alive	Alive
145	18.0	A	6	Dead twigs	Alive
146	27.9	A	6	Dead twigs	Alive
147	21.7	A	6	Alive	Alive
148	18.7	A	6	Alive	Alive
149	32.9	A	6	Dead twigs	Dying

tion of the final observations for all trees, made in the spring of 1948, is shown in the first four tables.

OBSERVED RESULTS

Poison Effect on the Tree

Poisoning effects could be observed several weeks after the poison had been applied. On those trees which were most severely affected by the poison, the needles started to fall before they had time to fade and change color and within a month or two almost all the needles had fallen. These were the trees which were classified as dead at the time of the next season's poison application.

For those trees not as severely affected by the poisoning, the effects assumed a quite characteristic pattern. This can be best summed up by saying that the top was dead, the middle was dying and the bottom was still completely green and alive-looking. This pattern held true for a large portion of the trees, but there were some exceptions. Those trees which were very slightly affected had scattered dead twigs or branches located at any point on the tree without showing any definite pattern in which the poison acted. There were also several trees that showed dead limbs in a spiral streak going up the tree. About two trees were observed to be dead except for a live tip in the crown. No attempt was made to ascertain why different trees reacted in such a varied manner to the same poison treatment. There is a good possibility that the differences may have been caused by some variation in the amount of poison applied, the peculiarities of the individual poison application or by individual tree characteristics. The top of the tree was probably affected first in most cases because the rate of transpiration is greatest there and it would dry out most rapidly after the cambium had been girdled.

A close check was made to find some correlation between poison effectiveness and tree vigor. No evidence of this could be found although there is a definite correlation between tree size and poison effectiveness. The smaller the tree, the more rapidly and completely will the poison take effect. In the tabulation of the final results, 44 of a total of 149 trees or 29.5% of all the trees poisoned are classified as dead while of those under 19" DBH, 27 out of 51 or 53% are dead. The smaller trees also showed the poison effects more rapidly. A small tree with wide poison spacing generally showed quicker and more severe symptoms than a larger tree treated with close poison spacing.

There is no doubt that Sodium Arsenite is very toxic to Western hemlock and small amounts will have a quite severe effect on the tree's physiological processes which may cause a gradual decline in vigor or immediate kill.

Tool Use

Determination of which tool was the best to use was done mainly through the relative ease of operation of the two tools. The plugcutter proved to have several distinct disadvantages as far as practical use is concerned. The plugcutting attachment can be easily driven into the tree to its full length, but if this is done some difficulty is encountered in removing it. In fact, whether driven in up to the hilt or not, it was often necessary to pump the handle up and down in order to loosen the cutter enough so that it would come out of the tree. This fault, though trivial when using the tool only a short time, rapidly runs into excessive work when poisoning is conducted for a longer period of time such as one-half day or more. The other disadvantage was due to the plugcutting attachment being offset from the head of the axe. This added length did not change the axe balance but when the axe was swung, the plughole always occurred a slight distance farther away than was expected. Though this could be partially compensated for when swinging the axe, accuracy was definitely impaired. Another factor which was bothersome but not serious is that the plugcutting attachment always started to cut into the tree a fractional part of a second before one expected to hit the tree due to the manner in which it extended beyond the axehead.

The notch and plug tool did not have any of the above disadvantages since the axeblade as well as the plugcutting attachment cut into the tree at about the same time. The balance of the axe was not upset nor the accuracy impaired due to the location of the cutter. This axe was as easy to recover from a swing as any ordinary double-bitted axe and could be used in about the same manner. In order to facilitate the dissemination of the poison it is desirable to use the axe in such a manner that the plughole will occur above the cut left by the axeblade. This restricts the use of the tool to right-handed axemen which is not the case with the plugcutter.

A little difference can be noted in the relative effectiveness of the axes in doing the job of poisoning as can be seen in Table 5. The notch and plug tool appears to have been slightly more effective. This can probably be attributed to better dissemination of the poison over a larger area due to the cut which accompanied the making of the plughole. Though the notch and plug tool does not cut as deeply and would not penetrate as thick bark as would the plugcutter, for the poisoning of a thin-barked species such as Western hemlock it is effective as well as being easy to use. The hole made by the notch and plug tool does not hold as much poison as the one made by the plugcutter but evidently this is compensated for by the fact that some of the poison that is applied immediately spreads along the axe-cut and

TABLE 5

Tool effectiveness in the summer poisoning test, according to final results for 100 paired trees.

Tree Condition	Number of Trees	
	Tool "A"	Tool "B"
1. Dead	17	15
2. Almost dead	23	23
3. Top dead	6	7
4. Dying	4	5
5. Dead twigs	0	0
6. Alive	0	0
	50	50

TABLE 6

Seasonal effectiveness of poisoning as tabulated from the final inspection in the spring of 1948 listing all trees treated.

Tree Condition	Percent of Total*			
	Spring**	Summer	Fall	Winter
1. Dead	48	32	6	0
2. Almost dead	30	46	44	0
3. Top dead	18	13	31	0
4. Dying	0	9	13	25
5. Dead twigs	0	0	0	0
6. Alive	4	0	0	75
7. Lost	0	0	6	0
	100	100	100	100

*Percent as calculated from the number of trees poisoned that season.

**The two Douglas fir that were poisoned have been eliminated as far as this calculation is concerned.

therefore the total amount of poison applied probably is about the same. A disadvantage to this is that there may be a break in the cut left by the axe or the ends of the cut may be open so that some of the poison runs out before it is absorbed and is lost. From the results obtained in the summer poisoning, this factor does not appear serious as the notch and plug tool still showed better results.

Season of Year

The results of the testing for seasonal effectiveness of poisoning do not indicate conclusively any exact time when poison application will yield the most satisfactory results. A quick glance at Table 6 will indicate that the winter season is entirely unsatisfactory for poisoning Western hemlock. Fall poisoning also does not seem to be as satisfactory as poisoning in the spring or summer. The spring poisoning produced the highest percentage of dead trees (48%) but if the first two condition classes are added together the results of spring and summer are exactly even at 78%. When adding the first three condition classes together, spring again appears more satisfactory with 96% while summer is not far behind with 91%.

A factor that must be kept in mind when examining these results is that the conditions of testing are not exactly comparable for the four seasons of the year.

There are a number of reasons which make the results appear at least slightly dubious. Not the same number of trees were poisoned in each season of the year, so the percentages are based on a varying number of trees which may be too few in number to produce valid results, particularly in the fall and winter tests. The amount of poison applied varies directly with the spacing of cuts, and trees at different seasons of the year received different amounts of poison due to this fact. Only the 6" spacing was used in every season of the year. When we calculate percentages according to the results of this spacing (Table 7) we find that spring shows the more conclusive results (100%) for the top two condition classes while summer has only 90%. Of course the spring results cannot be considered very significant because only two trees were poisoned at a six inch spacing in this season. The summer results on the basis of 20 trees definitely indicate that summer is a better time to poison than either fall or winter.

Considering the results of all the various spacings and the effects when a spacing of 6" is compared, the only conclusion that can be drawn is that spring and early summer affect poison effectiveness more than do fall and winter. It is entirely possible that an optimum time does exist somewhere in between the spring and summer poisoning dates. This optimum time probably varies to a considerable extent with variation in the start

TABLE 7

Comparison of seasonal effectiveness of trees poisoned at a six inch spacing.

Tree Condition	Percent of Total*			
	Spring	Summer	Fall	Winter
1. Dead	50	30	0	0
2. Almost dead	50	60	62	0
3. Top dead	0	5	25	0
4. Dying	0	5	13	25
5. Dead twigs	0	0	0	0
6. Alive	0	0	0	75
	100	100	100	100

* Total poisoned in that season.

TABLE 8

Tree condition for the summer poisoning as compiled according to spacing of cuts with the same amount of poison applied to each cut.

Tree Condition	Spacing				
	2"	4"	6"	8"	10"
1. Dead	15*	7	6	1	3
2. Almost dead	4	11	12	12	7
3. Top dead	1	2	2	4	5
4. Dying	0	0	0	3	5
5. Dead twigs	0	0	0	0	0
6. Alive	0	0	0	0	0
	20	20	20	20	20

* Number of trees in this condition.

of the growing season.

Spacing of Cuts

The method used to test for the spacing of the poison cuts does not actually isolate and test for this factor by itself. Because the amount of poison that was put into each hole was approximately the same, the number of holes cut in any one tree also determined the amount of poison that was applied. Therefore, any difference in reaction obtained by varying spacing can be the result of more poison or closer spacing of the poison or a combination of the two.

Since the poison kills the tree by girdling it, a closer spacing of the poison holes would tend to affect a larger portion of the cambium provided that lateral diffusion of the poison is limited. However, if lateral diffusion is good the better result could be just as easily obtained by placing more poison in fewer cuts. Therefore, to test the effectiveness of spacing it would either be necessary to know the amount of lateral diffusion or to conduct an experiment where the amount of poison applied to a given tree remained constant regardless of the number of cuts used to apply it.

The combined results of the spacing and amount of poison factors were varied, but in general tend to indicate that a spacing of 6" or less is quite effective, while over 6" it tends to become less effective as the cuts occur further apart. In Table 8 the tree conditions are tabulated according to the spacing of cuts for the group poisoned in the summer. The summer was the only season in which enough trees were treated with all spacing classes to make valid comparisons. In the fall the results indicated that a 6" spacing is better than a 12" spacing.

Results on Douglas Fir

Both Douglas fir trees poisoned showed no apparent ill effects. This can be attributed to several reasons among which are that the poison was applied too far apart, in too small a quantity, or perhaps the inheritant characteristics of the species makes it more resistant to poisoning. The latter may be the case as hemlock trees of the same size, given the same treatment during the same season showed the effects of poisoning.

CONCLUSIONS

This experiment definitely proved that the poisoning of Western hemlock with Sodium Arsenite is feasible. It required only a small amount of poison (1 gallon per 100 trees) and about 7 man-days of work under experimental conditions to poison all the trees and make the necessary inspections. Under ordinary conditions much less labor would be required and this system of poisoning could be effectively used to improve stand conditions at a reasonable cost. To obtain best results the notch and plug tool should be used at a spacing of 6" or less and poisoning should be done in the spring or early summer, the exact time varying with the start of the growing season. If this method is followed a fairly high percentage of kill should be obtained and all of the trees so treated should be reduced sufficiently in vigor that they can no longer offer serious competition to the more vigorous, younger trees growing about them.

There appears to be no delayed action effect if poison is applied during the dormant season. This seems to be borne out by the trees poisoned in the winter which almost all appeared alive in the middle of April. The trees poisoned in the other three seasons of the year generally appeared to become one condition class poorer by the next spring. An unanswered question remains as to whether these partially alive trees will gradually lose vigor and eventually die or if they will recuperate and put forth more foliage. This may be dependent on the amount of competition for light and moisture they encounter. Another factor which remains unanswered is the optimum combination of spacing and amount of poison required to effectively poison a tree. Perhaps if the poison holes were refilled several times not as many cuts would be required. This study indicates the general conditions for the poisoning of Western hemlock with Sodium Arsenite but the more detailed answers to these questions could be the basis for a more exhaustive study aimed at determing the exact optimum conditions under which the defective trees could be poisoned as a stand improvement measure.

SUMMARY

An experiment was conducted during the summer of 1947 at the Wind River Experimental Forest to determine the feasibility of using Sodium Arsenite poisoning as a stand improvement measure in Western hemlock stands. Results indicated that poisoning is fairly cheap, rapid, and produces effective results provided that attention is given to the method of poison application, the season of the year, the amount of poison, and the spacing of the cuts for application of the poison.

APPENDIX

The Notch and Plug Tool

Description of the plug attachment on the double-bitted swamping axe.

Inside diameter of sharp end	0.50"
Inside diameter of back end	0.60
Outside diameter of sharp end	0.55
Outside diameter of back end	0.90

The Plugcutter