

AN EVALUATION OF SIX METHODS FOR  
PROTECTING RED PINE STUMP TOPS  
FROM INFECTION BY FOMES ANNOSUS  
IN ONTARIO

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*Frontispiece.* An active sporophore of *Fomes annosus* attached to an infected red pine stump.

#### ABSTRACT

Dry borax was superior to aqueous solutions of sodium nitrite, sodium nitrite and ethanol, ammonium fluoride, malachite green, and suspensions of *Peniophora gigantea* oidia in preventing infection of fresh red pine stumps by *Fomes annosus*. The effectiveness of the treatments was evaluated after 6 months and again after 6 years. *Fomes annosus* had spread to some of the residual trees in all test areas except that in which the stumps had been treated with borax. Borax had the disadvantage of delaying breakdown of the stumps, while most of the other materials tested hastened this process. A more critical test of borax and sodium nitrite is being made and will be reported.

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Cover photograph shows an enlarged view of the pores found on the bottom surface of a *Fomes annosus* sporophore.



## INTRODUCTION

*Fomes annosus* (Fr.) Karst. is widely recognized as an important cause of root and butt rot in conifers. The windborne basidiospores of this fungus are capable of germinating on fresh stump tops, resulting in stump infection. Once in the stump, the fungus colonizes the root system and can pass, at points of root contact, into uninfected roots of neighboring trees or stumps.

Efforts to reduce the damage caused by *F. annosus* have been based largely on preventing stump infection. Stump treatment to prevent infection was first suggested and studied by Rishbeth (1949, 1959a, 1959b, 1963). Initially, covering the stump surface with creosote was recommended. This treatment, although fairly effective, delayed stump and stump-root decomposition, increasing the possibility that the stump roots could later become infected by contact with diseased roots. Subsequent studies proved other chemicals to be more satisfactory (Rishbeth, 1959b). As a result of Rishbeth's findings, borax received extensive testing in the United States (Sinclair, 1962; Driver, 1963a, 1963b) and was found to provide good stump protection. Gunderson (1963) showed that sodium nitrite protected stumps satisfactorily. Berry and Bretz (1964) recommended treating stumps with urea or ammonium fluoride. Rishbeth (1963) investigating biological control measures suggested that, as an alternative to chemical control, stumps could be protected against colonization by *F. annosus* by inoculations with the fungus *Peniophora gigantea* (Fr.) Massee.

In 1955 *F. annosus* was detected in pine plantations in southern Ontario (Jorgensen, 1956). A research program was initiated to evaluate the potential that this fungus has for becoming a problem in Ontario and to assess, under our conditions, the effectiveness of control measures in use elsewhere. As part of this program, a field test to compare six possible methods of protecting fresh stump tops from *F. annosus* invasion was conducted on the St. Williams Forest Station in southern Ontario.

## METHODS

An unthinned 2.8-acre plantation of 40-year-old red pine (*Pinus resinosa* Ait.), planted at a spacing of 6 x 6 feet, and free of *F. annosus* was selected in 1964. The area was divided into seven plots averaging 371 trees; each plot separated by one clear-cut row in which the stumps were treated with an aqueous solution of nickel sulfate (20% w/v). The plots were then thinned from September 1 to 4, and

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an average of 160 trees were removed from each plot. Within each of the seven plots, an average of 19 stumps were selected for each of the following treatments A to D and 33 stumps for treatment E.

- A. Immediate treatment with a stump protectant and inoculation with conidia (asexually produced spores) 24 hours later.
- B. Immediate inoculation with conidia and treatment 24 hours later.
- C. Immediate treatment with a stump protectant and inoculation with basidiospores (sexually produced spores) 24 hours later.
- D. Immediate inoculation with basidiospores and treatment 24 hours later.
- E. Immediate treatment with a stump protectant but not inoculated.

An exception was made in plot 3 where stumps in groups B and D only were inoculated immediately after felling and treated at intervals of 1, 6, 18 and 24 hours later, with 10 stumps being treated at each time period.

The materials tested as stump protectants were:

- Plot 1 - Borax ( $\text{Na}_2\text{B}_4\text{O}_7 \cdot 10 \text{H}_2\text{O}$ ) applied as a powder covering the stump top.
- Plot 2 - A 10% (w/v) solution of sodium nitrite ( $\text{NaNO}_2$ ) in 20% (v/v) ethanol ( $\text{C}_2\text{H}_5\text{OH}$ ) in water.
- Plot 3 - A 10% (w/v) aqueous solution of sodium nitrite ( $\text{NaNO}_2$ ).
- Plot 4 - *Peniophora gigantea* oidia (asexually produced infection bodies) in water.
- Plot 5 - Water.
- Plot 6 - A 10% (w/v) aqueous solution of ammonium fluoride ( $\text{NH}_4\text{F}$ ).
- Plot 7 - A 2.5% (w/v) aqueous solution of malachite green.

In plots 2, 3, 5, 6 and 7, the treatments were applied to the point of runoff. The conidia and basidiospores of *F. annosus* used as inoculum were suspended in water.



Stumps were first examined after 6 months. Disks, 2 inches thick, were cut from the tops of treated stumps, wrapped in moist newspaper, and incubated in galvanized cans. An average of 10 stumps from each treatment A to D and 15 stumps from treatment E were sampled from each plot. All the stumps in Plot 3 were sampled. After incubation, stump sections on which the imperfect stage of *F. annosus* could be found were considered infected.

Field examinations of the stumps were conducted once in 1969 and twice in 1970. All the stumps in each plot were examined carefully and were considered infected only if *F. annosus* sporophores were present. The number of trees infected by 1970, through root contacts with infected stumps, was determined similarly.

## RESULTS

Sampling in 1965 indicated that borax was superior to all other materials tested in preventing stump colonization by *F. annosus* (Table 1). Delaying treatment 24 hours did not necessarily result in more infection than was found in stumps treated immediately after the tree was felled (Table 1). Stump examination in 1970 revealed that borax had continued as the most effective stump protectant (Table 2). In 1965 and 1970 infection was less in all treated plots as compared with Plot 5, to which water alone had been applied (Tables 1 and 2).

Table 1. Treated stumps yielding *Fomes annosus* 6 months after thinning

Plot no.	Treatment applied <sup>b</sup>	Inoculation method <sup>a</sup>					Total yielding <i>F. annosus</i>
		Conidia		Basidiospores		Not inoculated <sup>c</sup>	
		A	B	C	D	E	
		% yielding <i>F. annosus</i>					
1	Na <sub>2</sub> B <sub>4</sub> O <sub>7</sub> ·10 H <sub>2</sub> O	20	10	10	0	13	10
2	NaNO <sub>2</sub> (10% w/v) in C <sub>2</sub> H <sub>5</sub> OH (20% v/v)	40	40	40	20	7	35
3	NaNO <sub>2</sub> (10% w/v)	40	40	20	30	0	32
4	<i>Peniophora gigantea</i> oidia	58	75	40	50	0	52
5	H <sub>2</sub> O	90	100	70	80	5	85
6	NH <sub>4</sub> F (10% w/v)	80	50	80	60	13	67
7	Malachite green (2.5% w/v)	90	80	20	80	13	67

<sup>a</sup> Inoculations under A and C were made 24 hours after treatment and under B and D, 24 hours before treatment.

<sup>b</sup> Treatment in plot 1 was applied as a powder, treatments in plots 2, 3, 5, 6, and 7 were aqueous solutions, and treatment in plot 4 was an aqueous suspension.

<sup>c</sup> These figures were not used in determining the total because stump infection here was dependent on natural inoculum only.



Table 2. Treated stumps bearing sporophores of *Fomes annosus* 6 years after thinning

Plot no.	Treatment applied <sup>b</sup>	Inoculation method <sup>a</sup>					Total % bearing sporophores
		Conidia		Basidiospores		Not inoculated <sup>c</sup> E	
		A	B	C	D		
		% bearing sporophores					
1	Na <sub>2</sub> B <sub>4</sub> O <sub>7</sub> ·10 H <sub>2</sub> O	0	6	0	0	3	2
2	NaNO <sub>2</sub> (10% w/v) in C <sub>2</sub> H <sub>5</sub> OH (20% v/v)	41	21	18	10	3	22
3	NaNO <sub>2</sub> (10% w/v)	60	70	20	0	4	37
4	<i>Peniophora gigantea</i> oidia	50	38	55	27	21	41
5	H <sub>2</sub> O	82	64	50	29	17	55
6	NH <sub>4</sub> F (10% w/v)	59	41	35	39	15	43
7	Malachite green (2.5% w/v)	47	35	29	29	21	35

<sup>a</sup> Inoculations under A and C were made 24 hours after treatment and under B and D 24 hours before treatment.

<sup>b</sup> Treatment in plot 1 was applied as a powder, treatments in plots 2, 3, 6, and 7 were aqueous solutions, and treatment in plot 4 was an aqueous suspension.

<sup>c</sup> These figures were not used in determining the total because stump infection here was dependent on natural inoculum only.

The data obtained from groups B and D in Plot 3, in which different periods elapsed between felling and application of chemicals, are given in Table 3. Analysis of this information by a chi-square test for independence revealed no significant differences in infection percentage owing to elapsed time of treatment application.

Table 4 shows the percentage of standing trees bearing sporophores, found in each plot in 1970. Plot 5, the water control (which had the highest level of stump infection), occupied the midpoint of this ranking. Plot 3, the sodium nitrite treatment, despite fair control of stump infection (Table 1), suffered one of the highest incidences of tree infection. Sixteen percent of the trees showing crown symptoms typical of trees infected by *F. annosus* did not bear sporophores and were not included in Table 4. These trees were distributed as follows: one in Plot 1, four in Plot 3, four in Plot 4, one in Plot 6, and four in Plot 7. Twelve percent of the total number of trees bearing sporophores exhibited no crown symptoms.

Table 3. Influence of delayed treatment with sodium nitrite on infection of stumps<sup>a</sup> by *Fomes annosus*

Time between felling and treatment (hr)	No. stumps	Inoculum	
		Conidia <sup>b</sup>	Basidiospores <sup>c</sup>
% yielding <i>F. annosus</i>			
1	10	20	0
6	10	30	10
18	10	40	30
24	10	40	30

<sup>a</sup> The stumps were sampled for *F. annosus* 6 months after inoculation.

<sup>b</sup>  $\chi^2 = 1.25$  with 3 df, not significant.

<sup>c</sup>  $\chi^2 = 4.67$  with 3 df, not significant.

Table 4. Residual trees bearing sporophores of *Fomes annosus* 6 years after thinning

Plot no.	Treatment applied <sup>a</sup>	No. trees standing	Standing trees bearing sporophores			No. stumps infected in 1965
			% living	% dead <sup>b</sup>	Total %	
1	Na <sub>2</sub> B <sub>4</sub> O <sub>7</sub> ·10 H <sub>2</sub> O	259	0.0	0.0	0.0	6
2	NaNO <sub>2</sub> (10% w/v) in C <sub>2</sub> H <sub>5</sub> OH (20% v/v)	218	1.4	1.4	2.8	15
3	NaNO <sub>2</sub> (10% w/v)	226	6.6	5.8	12.4	26
4	<i>Peniophora gigantea</i> oidia	227	4.8	4.8	9.6	25
5	H <sub>2</sub> O	180	5.0	1.6	6.6	35
6	NH <sub>4</sub> F (10% w/v)	172	9.3	2.9	12.2	29
7	Malachite green (2.5% w/v)	172	3.5	1.2	4.7	29

<sup>a</sup> Treatment in plot 1 was applied as a powder, treatments in plots 2, 3, 6, and 7 were aqueous solutions, and treatment in plot 4 was an aqueous suspension.

<sup>b</sup> A tree was considered dead if green needles could not be detected in the crown.

## DISCUSSION

The results of this study indicate that borax provides greater protection for red pine stumps against infection by *F. annosus* than do any of the other agents tested. This agrees with the results obtained for red pine by Sinclair (1962) and by Hadfield (1968). Sinclair,



however, used a 10% aqueous solution of borax, which we did not test in our study. Solid borax was selected because solutions often freeze during winter thinning operations. The application of a 10% aqueous solution of sodium nitrite to freshly cut stumps is currently recommended in Ontario as a means of preventing infection by *F. annosus* (Punter, 1968). Hadfield (1968) found a 5% solution of sodium nitrite to be of little value as a stump protectant on red pine in New England. The data obtained from the present study suggest that borax could be used as an alternative stump treatment. This treatment, since it did seem to prolong the life of a stump, could initially be recommended only for thinnings in plantations known to be free of *F. annosus* and only for red pine. Further comparisons with borax and sodium nitrite on red pine and jack pine (*Pinus banksiana* Lamb.) are being made.

One criticism of borax as a stump protectant, which seemed substantiated by our observations, is that it tends to prolong stump life. In the plot receiving the borax treatment, 76% of the stumps appeared sound in 1970 (Myren, unpublished). In the plot receiving only water, 52% of the stumps were sound, while all the other plots had lower percentages. Borax apparently did not kill the stumps to which it was applied but protected them by excluding many of the fungi capable of colonizing the living sapwood or the heartwood. It is likely that many of the borax-treated stumps and their roots will be present in the stand when most of the stumps receiving other treatments have been completely decayed. In borax-treated areas then, a longer period of time would exist during which a high root population would be present, and consequently, more avenues would remain available for spread by *F. annosus* if the fungus should become established. This could be very important if the stand became infected as the result of a second thinning.

Comparisons between Tables 1 and 2 show considerable differences in the percentage of infected stumps for the same plots. Data in Table 2 are probably conservative, as not every infected stump would bear a sporophore every year. Table 2 also includes some stumps that became infected through root contacts with those stumps that initially became infected as a result of our inoculations. It is possible that the stump surfaces exposed by removing a disk at 6 months for sampling were susceptible to infection, and any that occurred through those surfaces could contribute to the totals in Table 2. Twelve percent of the total number of stumps in plot 3 could have been infected in this manner, and in all other plots this percentage would be six or less. Undoubtedly some of these stumps were infected by secondary spread, however. A number of stumps that were infected in 1965 were, after careful examination, no longer considered so in 1970. These stumps were all sound, indicating functional root grafts with living trees. The advance of the fungus into these stumps may have been slowed to such an extent that the disk removed for the first sampling resulted in complete excision of the infected tissue. Every stump found infected in 1965 in the plot treated with borax was considered uninfected in 1970. In Plot 2, 33% of those



stumps initially regarded as infected were apparently free of infection in 1970, while the other plots had from 0 to 25% of those stumps uninfected.

The 24-hour delay between inoculation and treatment tested in Plot 3 gave protection not significantly different from that obtained when the delay was only 1 hour. The small number of stumps involved in this test, however, may not have given a true picture of the relationship. The variability of infection observed when treatments B and D are compared with A and C in Table 1 also suggests that a delay of 24 hours in the application of the stump treatment will not necessarily result in increased stump infection. Immediate treatment of the fresh stumps is still recommended, however, as delaying treatment could result in many stumps being missed. Further testing of this aspect of stump treatment is required.

The data in Table 4 must be examined in light of the number of infected stumps present in each plot in 1965, for it was from these stumps that the fungus passed into the living trees. Where the number of stumps infected was low, as in Plot 1, the number of trees bearing sporophores in 1971 was also low. In Plots 3, 4 and 6, the number of trees bearing sporophores seems particularly high when compared with the number in Plots 5 and 7. No explanation can be offered for the apparently more rapid spread observed in Plot 4, but in the plots treated with sodium nitrite and ammonium fluoride, spread may have been enhanced by the toxic action of these chemicals on the living stump tissue. There is also a possibility that translocation of the chemicals via root grafts predisposed these trees to infection. These observations indicated that in red pine some stump treatments may actually result in more rapid spread of *F. annosus* if infection should occur than would be found with no treatment.

Table 4 is probably conservative, as the presence of a sporophore was required before a tree was considered infected. The majority of those trees with crown symptoms but without associated sporophores were probably infected, and many additional trees probably had some degree of root infection. An increasing annual rate of tree death owing to *F. annosus* is anticipated as the disease pockets continue to expand within this stand.

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