

Borax Stump Treatment for Control of Annosus Root Disease in the Eastside Pine Type Forests of Northeastern California¹

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Abstract: A historical perspective and description of recent studies on the use of borax to treat pine stumps against infection by Heterobasidion annosum in eastside pine stands of northeastern California are presented. The studies indicate that boraxing of pines in eastside pine stands is an effective means of preventing annosus infection. Data and observations suggest that the lower stump diameter limit for treating chain saw-cut pines with borax could be raised from the currently recommended 8 inches (20.3 cm) to about 16 inches (40.6 cm) with little or no risk of creating active annosus root disease centers.

The eastside pine type forests of northeastern California lie in the region east of the Sierra Nevada-Cascade crest between the 4,000 and 6,500 foot (1220 and 1982 meter) elevations (fig. 1) where the climate is cold and dry and the principal tree species are ponderosa pine and Jeffrey pine (McDonald 1983). Other vegetation consists of varying amounts of western juniper, sagebrush, grasses, and occasional mountain mahogany. The incidence of Heterobasidion annosum in eastside pine type stands is especially high and locally damaging (Olson 1941; Wagener and Cave 1946), due to past heavy cutting of pines and an apparently favorable environment for the pathogen. Work by Bega and Smith (Bega and Smith 1966; Smith and others 1966) supported earlier statements of Meinecke (1914) and Wagener and Cave (1946) that increased forest management activity has contributed to an increased incidence of annosus root disease, with the greatest losses being associated with pine stumps left after thinning and harvest cutting operations.

This paper briefly discusses the history of the use of borax to treat tree stumps against infection by H. annosum in California, describes some recent studies on the incidence of annosus root disease in eastside pine type stands in relation to the use of borax and stump diameter, and concludes with a summary of the current status of borax use.

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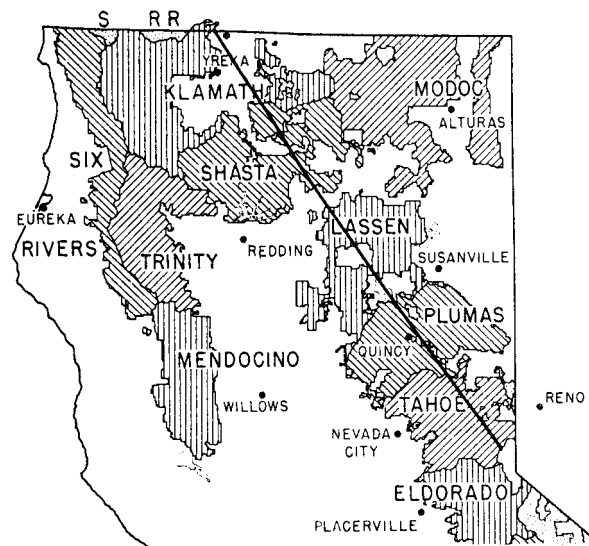


Figure 1. The eastside pine type forests of northeastern California lie in the area east of a line extending from Lake Tahoe northwestward to Highway 5 at the Oregon border.

HISTORICAL PERSPECTIVE

Recommendations for direct suppression or prevention of annosus root disease in California, based on research and surveys by Pacific Southwest Forest and Range Experiment Station and Pacific Southwest Region pathologists, were formulated in the 1960's. Direct suppression attempts in an area of high-value pines, which involved the pulling of stumps and fumigation (Bega 1962), proved too costly and impractical in most forest situations. Other control possibilities were suggested, but these either showed no promise under California conditions (biological control) or were not adequately field tested (the clear felling of trees around disease centers).

A silvicultural control method, which involved thinning during warm, dry periods unfavorable for growth of the fungus, was developed for eastside pine stands by R.S. Smith, Jr. (unpublished data³). High stump temperatures inhibited or blocked stump colonization by H. annosum in studies done in the southeastern United States (Gooding and others 1966; Ross 1973). Smith monitored stump

³Unpublished data on file, Pacific Southwest Region, U.S. Department of Agriculture, Forest Service, San Francisco, Calif.

temperatures of cut and inoculated ponderosa pine saplings and poles on the Lassen National Forest. Assays of discs cut from the stumps suggested that H. annosum will not survive the summer in stumps less than 6 inches (15.2 cm) in diameter because lethal temperatures above 104°F (40°C) are reached in the tops of the stumps.

Preventive measures such as chemical treatment of freshly cut stumps also were investigated in the 1960's. Choice of chemicals to test was based on success elsewhere (Berry and Bretz 1964; Hodges 1970; Driver 1963). High-nitrogen compounds (urea, ammate) that stimulate competing fungi, and borax, which is toxic to H. annosum spores, were tested in 1965 and 1966 on the Lassen National Forest. Results were inconclusive. In 1969, Graham (1971) demonstrated that treatment of 2- to 6-inch diameter Jeffrey and ponderosa pine stumps in young eastside pine stands on the Lassen National Forest with technical grade borax (sodium tetraborate decahydrate) prevented infection. After artificial inoculation with the fungus, less than 1 percent of the borax-treated stumps became colonized, but over 61 percent of the similarly inoculated but untreated control stumps became colonized. In 1969, Smith (1970) demonstrated that dry granular borax also prevented infection of white fir stumps, and did so to a greater degree than did a mixture of borax, water, and sticker.

By the early 1970's, observations and research discussed above had resulted in an accepted list of control recommendations, with the realization that prevention by treatment of freshly cut stumps with borax was the best recourse. In developed recreation sites, high-use areas, and areas with high-value trees such as seed orchards, treatment of stumps of all conifer species with dry granular borax immediately after felling was recommended because of the assumed high value of the trees. In timber stands, the use of borax needed to be justified by weighing the dollar cost of control against the dollar value of losses prevented. Treatment of all pine stumps during thinning or timber sales was recommended if damage by the fungus had been established.

True fir was not included in the recommendations for borax treatment in timber stands for several reasons, not the least of which was the low stumpage value of the species. Other reasons included the knowledge that H. annosum infects true fir through wounds as well as through stump surfaces, and the lack of pilot testing to demonstrate cost effectiveness on an operational basis.

Pacific Southwest Region pathologists (Byler and others 1978) developed a survey and subsequent benefit/cost analysis procedure to determine if application of borax to pine stumps is economically justified in eastside pine type stands. The procedure involves a strip cruise

of a proposed sale area to determine the proportion of stumps from previous cuttings that had become annosus infection centers. The assumption is made that, without treatment, the proportion of stumps that become infected and cause mortality centers in the upcoming sale will be similar to that of previous sales. Data collected are used to calculate the economic feasibility of borax treatment of stumps created from the proposed timber sale. The benefit of borax treatment is the product of the estimated impact resulting from the sale, the effectiveness of borax stump treatment (assumed to be 90 percent) and a present net worth factor (based on the discount rate and the number of years until harvest). A summary of the procedure follows:

BENEFIT/COST ANALYSIS FOR BORAX STUMP TREATMENT

$$1. \text{ IMPACT} = A \times B \times C \times D \times E$$

where: A = number of trees to be cut
 B = Pct stumps currently infected
 C = average center size (acres)
 D = yield at rotation (M bd ft)
 E = present stumpage value (\$/M bd ft)

$$2. \text{ BENEFIT/COST} = \frac{\text{IMPACT} \times F \times G}{H}$$

where: $F = \frac{1}{(1+i)^n}$ and n = years until harvest

G = treatment efficiency = 0.90
 H = treatment cost = number trees cut x \$1.00

3. PERTINENT INFORMATION

A = number of trees to be cut¹
 B = Pct stumps currently infected ..²
 C = average disease center size ...¹
 D = yield at rotation (M bd ft) ...¹
 E = present stumpage value (\$/M bd ft)¹
 i = interest rate (discount factor)see FSM 1971.71
 G = treatment efficiency0.90
 H = treatment cost\$1.00/stymp
 n = years until final harvest¹

¹ Information supplied by Forest/District

² Information obtained from survey

Initially, all proposed timber sales in eastside pine type forests were surveyed according to the procedure described above. Because results of these and other surveys indicated extensive areas of eastside pine with disease centers originating from stumps created by past cutting, it became forest policy in about 1978 on the Lassen National Forest to apply borax to all pine stumps in timber sales. At about the same time, incidence as high as 65 percent stump infection on some sale areas on

the Devils Garden Ranger District on the Modoc National Forest prompted the district to adopt the same policy.

A stump diameter limit for borax treatment, based on Smith's stump temperature studies, was added for pine in timber stands. Smith's research suggested that, because of the high, lethal temperatures reached in small diameter stumps, pine stumps less than 6 inches (15.2 cm) in diameter need not be treated with borax to control H. annosum infection. This lower diameter limit to treat was increased to 8 inches (20.3 cm) because observations indicated no spread of the disease from stumps created in pre-commercial thinnings.

Although the above recommendations for use of borax were once part of the Forest Service Directives System, the only directive now in effect is FSM 2303.14, R-5 Supp. 164, 9/86, which states..."To perpetuate the forest environment in and around developed recreation sites, treat all freshly cut coniferous tree stumps to prevent introduction and spread of Fomes annosus."

Suggestions for preventing or reducing the occurrence and the severity of annosus root disease in eastside pine type stands were summarized in 1982 (Smith 1983):

1. Because small stumps tend not to carry the infection, and solar radiation will kill H. annosum on or in the stump, thin eastside pine stands once, early and heavy, before the stumps reach 6 inches (15.2 cm) diameter.
2. Manage on an even-aged basis and minimize the number of entries after the trees reach pole-size.
3. Where survey of stumps from past cuttings indicates a stump infection rate of 5-10 percent or higher, consider treating all pine stumps larger than 8 inches (20.3 cm) in diameter with borax at the time of cutting.

As foresters and pathologists moved on to other positions or retired in the late 1970's and early 1980's and were replaced by others without the historical perspective and experience with annosus root disease, some of the reasoning behind the recommendations for borax treatment became vague, if not lost.

During the early 1980's, precommercial thinning of eastside pine type stands by mechanical shearing became an accepted and economical technique on portions of the Lassen National Forest and on the Doublehead Ranger District on the Modoc National Forest. The technique involves shearing standing trees at ground level. Because of the historical evidence of the impact of annosus root disease, the Lassen National Forest routinely boraxes all sheared pine stumps 8 inches (20.3 cm) or larger in diameter. The Doublehead Ranger District on the Modoc National Forest did not because of the lack of survey data indicating an annosus root

disease problem. A biological evaluation of the shear and stack technique in 1985 (Kliejunas 1985) suggested that, because stumps sheared at ground level may be more favorable for successful infection than stumps cut higher, and because of the known high rates of infection centers in other portions of the eastside pine type stands, treatment of sheared pine stumps 8 inches (20.3 cm) or larger with borax would be prudent.

RECENT SURVEYS

The 1985 evaluation, and questions from silviculturists, including why boraxing was routinely done on the Devils Garden Ranger District, but not on other districts on the Modoc National Forest, prompted several subsequent surveys and studies. The questions and results of the subsequent surveys and studies follow.

1. What are the current levels of annosus root disease in eastside pine type stands on the Modoc National Forest?

Surveys of similar stands on the Lassen National Forest have indicated that 5 to 15 percent of stumps from previous cuttings are infected (Smith 1983). The only historical information from the Modoc National Forest was from the Fletcher sale on the Devils Garden Ranger District, where 60 percent of the stumps were found infected in a 1975 survey (Byler and others 1978).

To determine the incidence of annosus root disease on the Modoc National Forest, ten 8- to 15-year-old sale areas were examined in May 1986 (Kliejunas 1986). Six of the sales were on the Devils Garden Ranger District and four on the Doublehead Ranger District. All sale areas were in eastside pine type stands. Stumps had not been boraxed in the sale areas.

In each sale area, a one-chain (20.1 meter) -wide strip survey was run for 20 to 40 chains (402 to 804 meters) parallel to a road. All stumps within the strips were measured for diameter and examined for the presence of H. annosum. If H. annosum conks were found in or on a stump, the stump was recorded as infected. If no conks were present, it was tallied as not infected. Dead and dying trees around the stumps were noted and estimates of area of root disease centers were made. The total area sampled varied in each sale area.

Results from the ten sale areas examined are presented in table 1. Stump infection averaged 50 percent, ranging from 20 percent on the Timbered Ridge sale to 80 percent on the Craig Spring sale. Levels of stump infection were low on the Crowder, Timbered Ridge, and Cupboard sales, but still were over 20 percent.

Table 1--Incidence of pine stump infection by Heterobasidion annosum on ten non-boraxed timber sale areas surveyed in 1986 on the Modoc National Forest

Sale	Year cut	Area sampled	Pine Stumps infected ¹		Active infection centers ²	Dead pines ³	
		<u>Acres</u>	<u>No.</u>	<u>Pct</u>	<u>Total</u>	<u>Per acre</u>	<u>No.</u>
Devils Garden R.D. ⁴							
Craig Spring	1970	4.0	39/49	80	12	3.0	21
Everly	1971	3.5	14/35	40	8	2.3	22
Knobcone	1973	4.0	38/54	70	13	3.3	50
Widow Valley	1974	4.0	28/51	55	8	2.0	31
Poindexter	1976	2.0	19/40	48	4	2.0	5
Crowder	1977	2.0	9/40	23	3	1.5	6
Doublehead R.D.							
Warm Springs	early 70's	4.0	22/40	55	7	1.8	14
Bird Springs	mid-70's	4.0	26/36	72	11	2.8	54
Timbered Ridge	mid-70's	4.0	7/35	20	1 ⁵	0.3	2
Cupboard	late 70's	3.5	11/42	26	0 ⁵	0.0	0
TOTALS		35	213/422	50	67	1.9	205

¹ Ratio of the number of stumps with conks of H. annosum to the total number examined.

² Based on the presence of at least one dying or recently dead pine adjacent to the stump infected by H. annosum. An area with more than one stump associated with the dying or recently dead trees was counted as one active annosus root disease center.

³ Total number of dying or recently dead pines adjacent to stumps infected by H. annosum.

⁴ R.D. = Ranger District.

⁵ The area was recently thinned with mechanical tree shearer. This thinning would have removed dead or dying trees in the vicinity of stumps remaining from previous timber sales.

Size of annosus infection centers varied. In many cases only one or two dead or dying pines were associated with each infected stump. In some sale areas (Knobcone, Craig Spring, and Bird Springs) however, dead and dying pines within areas of an acre (0.4 ha) or more were associated with infected stumps. Recently dead or dying sapling, pole, or sawtimber-sized ponderosa pines on the Knobcone and Bird Springs sales averaged about 12 trees per acre (0.4 ha). Juniper and sagebrush also were infected with H. annosum in these root disease centers.

The number of active annosus root disease infection centers varied from none on the Cupboard sale to 3.3 per acre (0.4 ha) on the Knobcone sale, and averaged 1.9 infection centers per acre (0.4 ha) for all sales. If, by conservative estimate, each active center averaged 0.1 acre (0.04 ha), then about 20 percent of each acre (0.4 ha) surveyed was out of production due to annosus root disease. In terms of the total survey, trees on 7 (2.8 ha) of the 35 acres (14.2 ha) examined were infected by H. annosum.

The actual numbers of infected stumps in the sale areas examined on the Modoc National Forest were probably higher than recorded because only stumps with conks were counted as infected. These high rates of infection, as evidenced by the number of dead pines, result in at least 20 percent of each acre (0.4 ha) being currently out of production. Since H. annosum can survive in infected stumps for many years, a conservative estimate is that about one fifth of the area in non-boraxed timber sales in the eastside pine type on the Modoc National Forest will not produce merchantable pines for the next 20 to 40 years.

2. Is boraxing of pine stumps in eastside pine type stands actually beneficial?

In 1987, six 5- to 11-year-old sale areas (three on the Modoc National Forest and three on the Lassen National Forest) where stumps were

Table 2--Incidence of pine stump infection by Heterobasidion annosum on boraxed and non-boraxed timber sale areas on the Modoc and Lassen National Forests.

Forest	Sale Area	Year cut	Year surveyed	Boraxed	Acres sampled	Pine stumps infected	
						<u>No.</u> ¹	<u>Pct</u>
Modoc	Fletcher	1976-77	1987	yes	11	2/100	2
	Crowder	1977	1986	no	2	9/40	23
	Knobcone Fire	1978-79	1987	yes	2.8	1/50	2
	Wart	1980-81	1987	yes	4.1	3/70	4
	Knobcone	1973	1986	no	4.0	38/54	70
Lassen	Mt. Home	1977	1987	yes	6.1	1/50	2
	Juniper	1978	1987	yes	3.7	1/50	2
	Suicide	1978-79	1987	yes	3.4	0/25	0

¹Ratio of the number of stumps with conks of H. annosum to the total number of stumps examined.

boraxed at the time of cutting were examined (J.T. Kliejunas, unpublished data⁴). A one-chain-wide strip survey as previously described was used, and all stumps created during the most recent sale that were within the strip were examined for the presence of H. annosum. These data were then compared to those of the 1986 survey.

Results are presented in table 2. On the three boraxed sales on the Modoc National Forest, 2 to 4 percent of the stumps were infected. The Fletcher sale is adjacent to the non-boraxed Crowder sale area examined in 1986. Only 2 percent of the stumps in the boraxed Fletcher sale were infected compared to 23 percent in the non-boraxed Crowder sale. The non-boraxed Knobcone sale is located between and within a few miles of the boraxed Wart and Knobcone Fire sales. Four and two percent of the stumps in the boraxed Wart and Knobcone Fire sales, respectively, were infected, compared to 70 percent in the non-boraxed Knobcone sale.

From none to 2 percent of the stumps examined on the three boraxed sales on the Lassen National Forest were infected. Some historical information on the Mt. Home and Juniper sales exists. Pre-sale surveys in 1975 by Forest Pest Management found that 15 percent of stumps from previous cuttings were infected with H. annosum. Based on the assumption that, without borax treatment, about 15 percent of the stumps created would be infected, the decision was made to borax. About 10 years after borax treatment, only 2 percent of the boraxed stumps were infected.

⁴Unpublished data on file, Pacific Southwest Region, U.S. Department of Agriculture, Forest Service, San Francisco, Calif.

3. If boraxing is done, what diameter class of stumps should be treated?

Policy regarding lower limits of stump diameter to treat with borax varies by forest and district, depending largely on historical information, current observations, and other considerations. In 1985, thinned ponderosa pine stands on the Hat Creek Ranger District on the Lassen National Forest were surveyed to determine the lower limit of stump diameter on which H. annosum is not an effective pathogen in eastside pine type stands, rendering borax treatment unnecessary (DeNitto 1985).

Only eight of 83 mortality spots checked did not have stumps greater than 18 inches (45.7 cm) in diameter as an apparent source of infection. Two of these eight centers had no obvious source (within reasonable limits), and the remaining six centers had numerous small stumps as possible sources of infection.

The present policy on the Lassen National Forest in eastside pine type stands is to use borax on all commercial timber sales. Borax is not used in precommercial thinnings, except in those that are mechanically sheared. In general, stumps in precommercial thinnings are 8 inches (20.3 cm) or less in diameter. The survey results support that policy.

Stump diameters were measured during a survey on the McCloud Ranger District, Shasta-Trinity National Forests, in 1988 (DeNitto 1988). The survey objective was to determine the levels of annosus root disease in eastside pine stands and mixed conifer stands with previous harvesting activity. Two mixed conifer stands had an average of 4 percent of the stumps infected, and four eastside pine stands averaged 18 percent stump infection.

Figure 2 presents a summary of the percentage of stumps infected by diameter class for the four eastside pine stands. Results suggest that stumps less than 14 inches (35.6 cm) in diameter will not support active annosus infection centers.

The 1986 survey on the Modoc National Forest (Kliejunas 1986) also revealed a relationship between stump diameter and infection (table 3). Although the data should be interpreted with caution because of the low numbers of stumps 12 inches (30.5 cm) or less in diameter, larger diameter stumps were more likely to be infected than smaller diameter stumps.

4. What is the incidence of infection of sheared stumps by H. annosum, and are stumps sheared at ground level actually more favorable for infection?

Some information on the incidence of infection of sheared stumps by H. annosum is available (J.T. Kliejunas and W.J. Otrosina unpublished data⁵). In 1986 and 1987, 14 mechanically sheared stands on the Doublehead Ranger District were selected according to time since shearing and time of year that shearing occurred. Discs or wood chips were collected by diameter class from 10 randomly selected sheared stumps in each stand and samples were incubated to determine colonization by H. annosum. The fungus was present in 4 of the 14 stands. The four stands were thinned 1 or 2 years previous to sampling and at all seasons of the year.

To determine whether sheared stumps are more favorable for infection by H. annosum than stumps cut by chain saw, a stump temperature study similar to R.S. Smith Jr.'s needs to be done. The hypothesis is that stumps cut at ground level and often covered by duff are more favorable for infection owing to lower temperatures and higher moisture.

DISCUSSION

The studies and observations summarized in this paper indicate that boraxing of pines in eastside pine type stands is an effective means of preventing annosus infection and reducing future losses. These studies also suggest that, in timber sales, the diameter limit for treating with borax could be raised from 8 inches (20.3 cm) to "commercial" trees. In eastside pine type stands, "commercial" can vary from about a 12-inch (30.5 cm) diameter stump in normal sales to 16 to 18 inches (40.6 to 45.7 cm) in fire salvage sales. Although one research study (R.S. Smith, Jr., unpublished data) indicated

⁵Unpublished data on file, Pacific Southwest Region, U.S. Department of Agriculture, Forest Service, San Francisco, Calif.

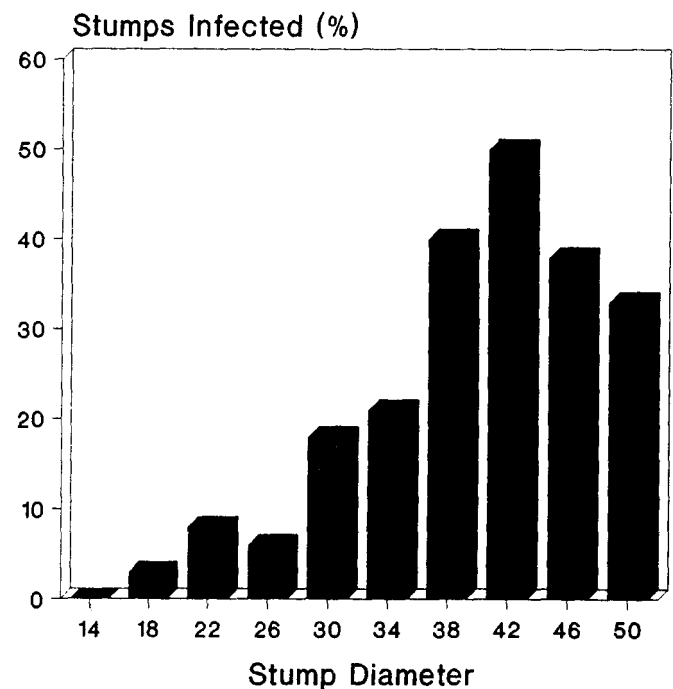


Figure 2. Percent of pine stumps infected by Heterobasidion annosum by diameter class.

Table 3-- Ponderosa pine stumps with conks of Heterobasidion annosum, by diameter class, on ten non-boraxed timber sale areas on the Modoc National Forest

Stumps			
Diameter	Total observed	With conks	Infected
Inches	No.	No.	Pct
12 or less	20	0	0
14 to 18	7	0	0
18 to 22	12	2	17
22 to 26	29	10	35
26 to 30	73	30	41
30 to 34	88	45	51
34 to 38	86	52	60
38 to 42	62	42	68
42 or more	45	33	73

that stumps 6 inches (15.2 cm) in diameter and larger in eastside pine type stands are susceptible to infection, field observations only rarely indicate H. annosum spreading from pine stumps less than about 16 inches (40.6 cm) in diameter and causing active annosus root disease infection centers. The diameter of stumps susceptible to infection may well be smaller than the diameter needed to successfully carry H. annosum to adjacent live trees.

The decision as to what lower stump diameter limit to treat with borax should be based on the risk the forest or district is willing to take versus the cost of the borax treatment. When thinning by mechanical shearing, which creates stumps at ground level often covered by duff, the risk of infection may be greater. Since the oldest sheared stands in the eastside pine type are only about 10 years old, active centers may not have had time to develop. Until more information is available, the decision as to the lower limit at which to treat sheared stumps should be weighted toward the 8-inch (20.3-cm) limit indicated by research results.

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