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ESTABLISHMENT REPORT: PERMANENT PLOTS TO EVALUATE THE EFFECTS OF ARMILLARIA ROOT DISEASE IN PRECOMMERCIALLY THINNED STANDS

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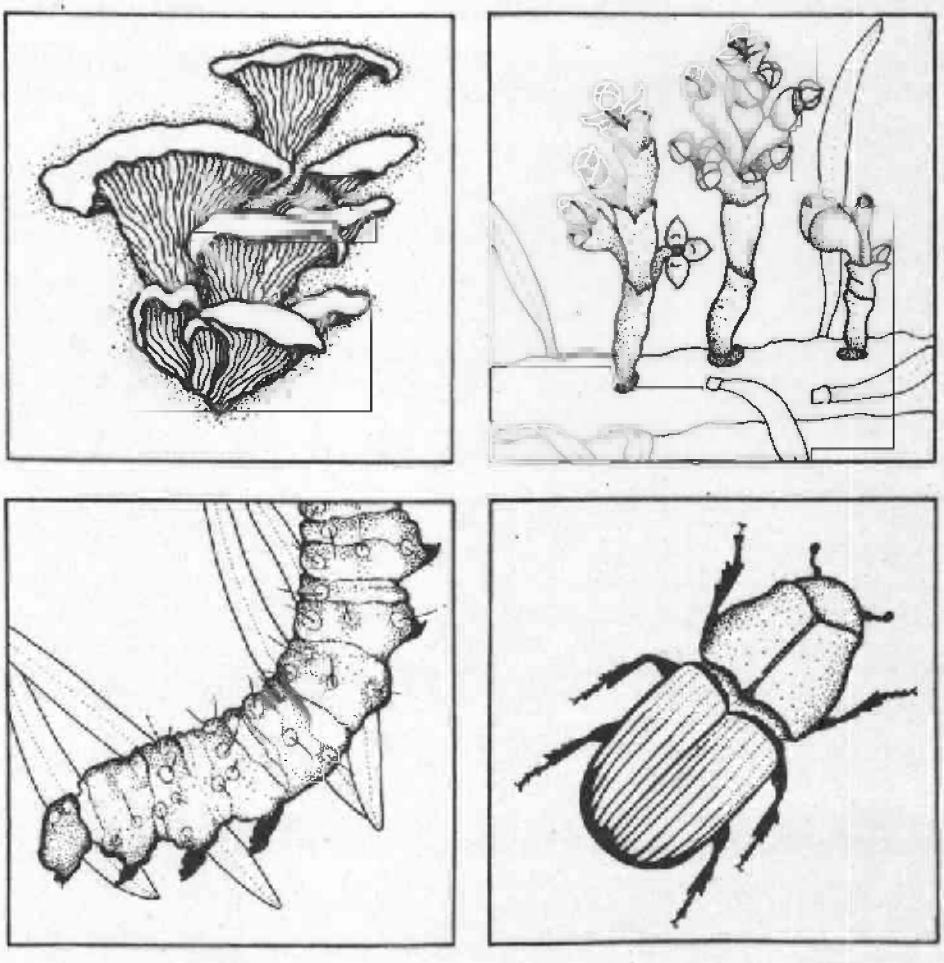

ESTABLISHMENT REPORT: PERMANENT PLOTS TO EVALUATE THE EFFECTS OF ARMILLARIA ROOT DISEASE IN PRECOMMERCIALLY THINNED STANDS

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ABSTRACT

Methods used to establish permanent plots in precommercially thinned and unthinned stands to monitor root disease development are described. Plots were established in 22 Armillaria-infested stands in northern Idaho and western Montana. The proportion of trees dead and infected was significantly higher for planted than for natural regeneration at the time of plot establishment.

INTRODUCTION

Armillaria root disease, caused by Armillaria sp.[2], is common in the forests of Montana and Idaho (James, et al. 1984), Oregon and Washington (Filip 1977, Shaw & Roth 1978), and British Columbia (Morrison 1981). Root disease centers of tree mortality and stands with scattered tree killing occupy a sizable proportion of the commercial forest land in some Region 1 National Forests (James et al. 1984), and Armillaria is associated with much of this tree mortality. Surveys in merchantable stands indicate that cumulative losses over a rotation can be significant.

Armillaria root disease is also common in plantations and young growth stands. It is evident in these stands as scattered killing of individual trees and small groups, often near stumps that serve as food bases for the pathogen.

It is generally assumed that the pathogen will adversely affect the growth and development of these young-growth stands. However, the effects have not been quantified. For this reason, permanent plots have been established in 22 diseased young-growth stands on five National Forests in Region 1 to monitor the effects of root diseases. These root disease evaluation plots supplement the Region's growth and yield permanent plots, some of which also have root disease.

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[2] Armillaria mellea has been assumed to be the cause of Armillaria root disease in the northern Rocky Mountains and Intermountain West. However, recent authors in Canada and the western United States indicate the cause may be Armillaria ostoyae.

Our initial hypotheses, based on Morrison (1981) and observations in this Region, are as follows. Above normal rates of tree mortality will take place in all conifer species until about age 25-30, when rates for western larch and the pines will decrease. Rates for Douglas-fir and true firs will remain high. The long-term effect of disease will be to favor pines and larch where present, and to reduce stocking. Plots with little pine and larch will develop into nonstocked or poorly stocked root disease centers. Planted trees will be killed at higher rates than natural regeneration, especially when less than 30 years of age. Precommercial thinning that leaves Douglas-fir, true firs, planted pines, or planted larch combined with high mortality rates may lead to an understocked condition for a time.

The goal of this project is to evaluate the long-term effects of Armillaria root disease on stand growth and yield. Specifically the objectives are to:

1. Measure mortality rates expressed as average number of trees killed per acre per year caused by the disease,

2. Determine the effects of tree species, tree age, regeneration method (planting vs. natural) and treatment (precommercial thinning) on mortality rate, and,

3. Measure the long-term effects of Armillaria-caused mortality on stand species composition, stocking and volume.

METHODS

The root disease plots were established during the 1983 and 1984 field seasons to supplement the Region's timber growth and yield permanent plots. Timber growth and yield plots have been established throughout the Region during the past few years. Clusters of three 1/20-acre plots are randomly placed within selected stands (Timber Management Handbook 2409.21--12).

Stands were selected for root disease evaluation plots as follows. A list of candidate stands was obtained from Forest and District foresters and silviculturists, giving priority to stands with timber growth and yield plots. These stands were examined for root disease and selected or rejected based on the following stand selection criteria:

1. Armillaria root disease was sufficiently present to allow placement of control and treatment plots in the same stand.

2. The stand was suitable in size and stocking to be precommercially thinned.

3. A mix of tree species was present.

4. The final plot list would include stands well distributed over the six timber-producing Forests with significant Armillaria mortality.

In all, 22 stands were selected, most of which met all of the above criteria. Four of these also contained timber growth and yield plots. Timber growth and yield plots in 23 additional stands were examined for root disease. Ten of these stands had Armillaria-associated tree mortality.

In 1983, stands selected for sampling were surveyed for root disease before permanent plots were established. Random plots were used to evaluate the stand condition (T/A by species) and root disease condition (percent plots affected and percent of trees dead or declining). This survey was dropped during the second year because of time constraints.

Plots were established according to the methods described in the study plan using the R-1 stand exam forms and procedures for permanent plot data collection. The plots were one-twentieth acre in size. Two three-plot clusters were established in each stand. One plot was thinned, and one was left unthinned.

Leave trees were selected using R-1 guidelines and practices. All plot trees were examined for root disease (before thinning on the thinned plots). All trees were tagged (after thinning on thinned plots).

Plot locations were not selected randomly, but placed in preselected portions of the stand that met the following criteria:

1. Armillaria root disease was present.

2. Adequate stocking was present so that future mortality could be monitored.

The goal was to make plots representative of the diseased portion of the stand. Thirty-five mm color slides were taken from plot center at the plots established in 1984.

Data from the 22 diseased stands, but not the additional TM stands, were summarized using INDIDS (Bousfield 1980). Analysis of variance and t-tests were run on the arc sine of the percentage of trees per plot unaffected by root disease. Tukey's Multiple Range Test was used to test significance of regeneration method, tree species, tree size, and habitat type on percent of trees killed or symptomatic.

The intent is to reexamine the plots at intervals of 5 years following an initial reexamination after 2 years. Diameter at breast height, root disease rating, and tree condition (live or dead) will be recorded for each tree on each exam. Mortality rates will be calculated for different stands, treatments, and tree species.

Appendix A is a summary of the surveyed stands and their locations.

RESULTS

Stand summaries were made and statistics were calculated to describe root disease conditions in the stands at the time of plot establishment. Most objectives of the project can only be met following a minimum of 1 to 2 reexaminations of the plots, made 2-12 years after plot establishment. Following are summaries of plots located in disease portions of 22 precommercial stands.

ARMILLARIA DAMAGE. Armillaria was the only root pathogen detected on most plots, although a thorough examination for other pathogens was not made. Figure 1 illustrates the current amount of mortality on the permanent plots with root disease. In most stands, about 5 to 10 percent of the plot trees per acre were dead. We estimate this mortality occurred over approximately a 5-year period. If so, the average annual mortality rate on the diseased plots is between 1 and 2 percent.

A substantial proportion of the trees on disease plots was also infected and showing symptoms of disease (figure 1). Symptoms included thin and/or discolored foliage, and resin flow at the root collar. Overall, about one-third fewer trees were symptomatic than were dead at the time of plot establishment. Appendix B summarizes the numbers and percentages of the plot trees in each stand that were symptomatic (infected) and the number killed.

FACTORS AFFECTING MORTALITY. Data from diseased permanent plots in the 22 stands were analyzed to determine whether the percent of dead and infected trees was related to regeneration methods, tree species, tree size, or habitat type series.

A significantly higher proportion of planted trees was affected by Armillaria root disease than was natural regeneration. The average percentage of planted trees[3] of all species that were dead or symptomatic was 26.6. The average for natural regeneration was 8.7 percent. The difference was significant at the 99 percent level. The relationship held for Douglas-fir and true firs analyzed as a group (planted 23.1, natural 10.7); and for western larch, ponderosa pine, white pine, and lodgepole pine group (planted 24.4, natural 7.5).

Tree species were also grouped to test the hypothesis that Douglas-fir and true firs (grand fir and subalpine fir) were more damaged by Armillaria than were western larch and pines (ponderosa pine, lodgepole pine, western white pine). While a higher percentage of firs was affected than larch and pines, 12.8 compared with 7.0, the difference was not significant.

An attempt was made to determine whether infected trees differed in size (d.b.h.) from unaffected ones. While the mean diameter of diseased trees (2.3 inches) was somewhat larger than the average (1.5 inches), the difference was not statistically significant.

Plot data were also summarized by habitat type series, Douglas-fir, grand fir, cedar/hemlock, and subalpine fir. No difference was apparent in the percentage of trees affected by Armillaria in different series. Of the 41 clusters examined, the representation by habitat type was Douglas-fir series 11, grand fir series 5, cedar/hemlock series 5, and subalpine fir series 11.

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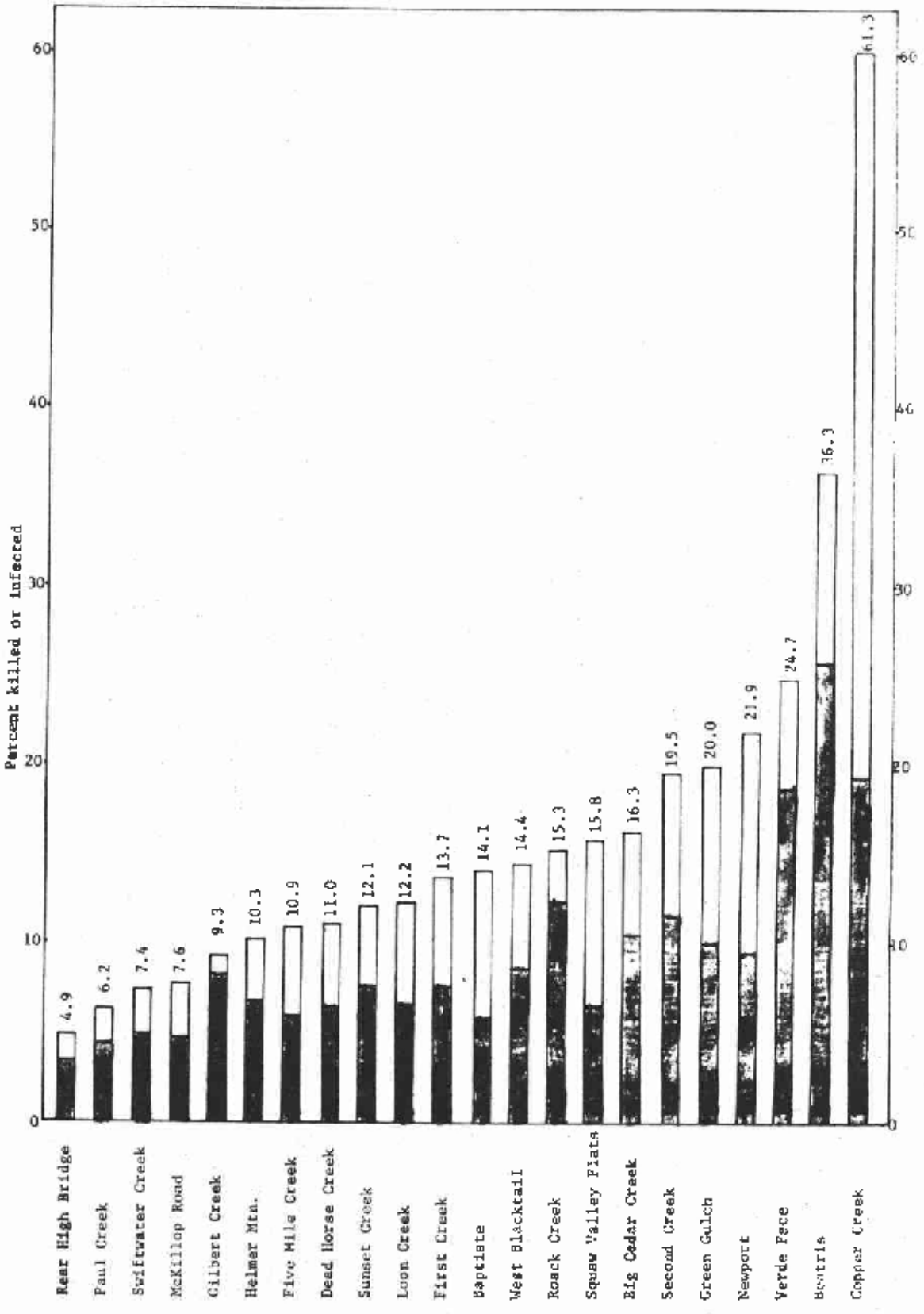
[3] When both natural regeneration and planted trees of the same species were present in a stand, all trees of that species were included in the "planted" category because of difficulty in distinguishing planted individuals from naturals.

Figure 1.--Percentage of trees killed (shaded) and infected (unshaded) by Armillaria root disease on the permanent plots with root diseases (control and treatment plot data were combined).



DISCUSSION

The most significant result so far is that about three times as many planted trees were affected by Armillaria as were naturally regenerated trees. The increased susceptibility of planted trees has been noted by others (Shaw & Roth 1978). The reason for this is not known. The difference may be due to a mismatch of planting stock to the site (seed source), poor root growth due to improper planting, or planting in the shade of stumps, a practice that may increase the likelihood of infection.

Our inability to demonstrate a difference in species susceptibility was also not surprising. All conifer species are susceptible at a young age (Morrison 1981). Most of our stands were less than 30 years of age.

We currently recommend regenerating Armillaria-infected areas with western larch or pine rather than Douglas-fir and true firs, and we don't believe it is advisable to change that recommendation. We anticipate that future examinations will show a relative decrease in pine and larch mortality.

Permanent plots were subjectively placed in root-diseased portions of the stand. An attempt was made to determine whether these plots were representative of diseased portions of the stand. Summaries were made of plot data from six stands surveyed in 1983, stands that had a three-plot cluster in a portion not to be thinned, and diseased plots on transects of randomly placed plots to sample the stands. The percentage of affected trees on the random plots was similar to that from permanent plot clusters located in diseased portions of the stand (table 1).

We conclude that the permanent plots can be considered representative of those randomly placed plots that have diseased trees. An approximation of stand loss can be projected from the mean loss on permanent plots multiplied by the proportion of random plots that are diseased.

Large-scale black-and-white photographs that predated harvest were available for many of the stands. These were examined to determine whether root disease centers were visible in the previous stands. No centers were visible, and we concluded that most of our plots fell in locations that were not centers.

Table 1.--A comparison of the percentage of trees affected by Armillaria on different plot types in the same stands.

Stand	Percent dead or infected			% plots with root disease[3]
	Control	Treatment[1]	Random[2]	
379	36	15	19	47
347	7	11	12	35
663	22	-	18	9
847	8	3	7	36
833	15	14	15	50
848	30	10	25	63

[1]Data from 3-plot clusters collected before plot was thinned.

[2]Randomly selected 1/10-acre plots along transects through the stand. Data summaries are for plots with infected trees only.

[3]Percent of random plots that had at least one Armillaria-infected or killed tree.

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APPENDIX A

STANDS WITH PERMANENT PLOTS: ROOT DISEASE AND/OR TM GROWTH AND YIELD

The following table lists 45 stands on six National Forests that have either timber growth and yield plots or root disease evaluation plots, or both. All stands were checked for root disease during 1983 and 1984. Of these, 32 stands are of precommercial size and contain permanent plots with Armillaria root disease. Twenty-two have root disease plots that were located in diseased portions of the stand, and 10 others have randomly selected TM growth and yield plots on which Armillaria is present. Two stands had Armillaria, but plot trees have not been examined for root disease. All 34 should be reexamined for root disease mortality in the reinspection years. Additional growth and yield plots may have Armillaria, but were not examined.

APPENDIX A
STANDS WITH PERMANENT PLOTS:
ROOT DISEASE AND/OR TM GROWTH AND YIELD

Forest	District	Stand #	Unit	Exam type/ Exam date	Root disease condition	Type plots Disease	Type plots TM	Date of last inspection	Comments
CLWT	Pierce	109-05-011	Brady Cr.	1	Armillaria	-	x	1987	
		109-07-004	Lolo Cr.	1	None	-	x	1988	
	Lochsa	520-07-006	W. F. Pete King Cr.	1	Armillaria	-	x	1988	
		520-08-011	Jungle Pt.	1	Armillaria/ Annosus	-	x	1988	Commercial
	Kelly Cr.	414-02-004	Osier Cr.	2	None	-	x	1988	
		414-01-001	Deception Saddle	2	None	-	x	1987	
		413-03-004	Independent Cr.	2	None	-	x	1988	
		313-03-036	Independent Ridge	2	None	-	x	1988	
	Palouse	253-03-005	East Dennis	2	Phaeolus	-	x	1986	Commercial
FLHD	Spotted Bear	446-06-001	Baptiste Cr.	-	Armillaria	x	x	1986	
IPNF	Fernan	346-01-001	Laverne Saddle	1	Armillaria/ Phellinus	-	x	1988	
		301-08-013	Echo Peak	2	Armillaria	-	x	1989	
	Sandpoint	663-02-002	Newport	-	Armillaria/ Annosus	x	-	1985	
	Priest River	847-02-002	Rear High Ridge	-	Armillaria	x	-	1986	
		833-03-001	West Blacktail	-	Armillaria	x	-	1986	
		847-02-002	Squaw Valley	-	Armillaria	x	-	1986	
	Bonners Ferry	731-04-015	Copper Cr.	-	Armillaria	x	-	1986	
	Wallace	199-04-016	Thompson Pass	2	Armillaria	-	x	1989	
		199-04-018	Thompson Pass	1	None		x	1989	
		154-04-005	Road 152.5	1	Armillaria	-	x		

1 = TM plots re-examined
2 = Stand walk through
3 = Roadside

APPENDIX A, cont.

Forest	District	Stand	Unit	Exam type/ Exam date	Root disease condition	Type plots Disease	Type plots TM	Date of reinspection	Comments
KOOT	Cabinet	704-06-015	S. F. Bull R.	1	Armillaria	-	x	1989	
		702-01-003	Dead Horse	-	Armillaria	x	-	1986	
		703-07-001	Green Gulch	-	Armillaria	x	-	1986	
	Fortine	342-03-001	Paul Cr.	-	Armillaria	x	-	1986	
	Rexford	119-03-004	Helmer Mt.	-	Armillaria	x	-	1986	
	Fisher R.	607-01-061	Five Mile	-	Armillaria	x	-	1986	
		614-04-005	McKillop Rd.	-	Armillaria	x	-	1986	
LOLO	Missoula	347-06-033	Gilbert Cr.	-	Armillaria	x	-	1985	
		379-01-034	Verde Face	-	Armillaria	x		1985	
	Nine Mile	418-04-010	Rock Cr.	-	Armillaria	x	x	1985	
	Superior	765-01-018	First Cr.	-	Armillaria	x	x?	1986	
		763-01-047	Second Cr.	-	Armillaria	x	-	1986	
		743-01-001	Sunset Cr.	-	Armillaria	x	-	1986	
	Thompson Falls	831-01-019	Beatrice Cr.	-	Armillaria	x	-	1986	
		527-03-010	Compbest Cr.	1	Armillaria	-	x	1990	
NEZP	Selway	716-01-104	Big Cedar Cr.	-	Armillaria	x	x	1986	
		702-02-006	Swiftwater Cr.	-	Armillaria	x	-	1986	
	Red River	509-04-002	Loon Cr.	-	Armillaria	x	-	1986	
	Clearwater	422-02-005	Twin Cabins	1	Armillaria	-	x	1988	
		421-02-027	Tollgate Spruce	1	Armillaria/ others	-	x	1986	
		409-01-021	Blacktail Butte	2	Armillaria ?	-	x	1988	Commercial
		303-01-008	Jungle Pk.	1	None	-	x	1989	
		303-01-003	Shells Lick	1	Armillaria	-	x	1988	
		420-03-007	Cove	2	None	-	x	1987	
		422-01-004	Cold Springs	1	Armillaria	-	x	1989	

Appendix B.--A summary of Armillaria infection and mortality on infested permanent plots.

Unit name	Stand no.	Treatment	Species total Infected T/A	Infected %	Mortality T/A	Mortality %	Total T/A
Squaw Valley Flats	848-01-003	C	93.3	19.7	46.7	9.9	473.3
West Blacktail	833-03-001	C	6.7	1.4	66.7	13.7	486.7
Rear High Bridge	847-02-002	C	46.7	2.6	86.7	4.9	1786.7
Rock Creek	418-04-010	C	26.7	1.9	126.7	8.8	1433.3
Verde Face	379-01-034	C	43.3	5.7	500.0	30.4	1646.7
Gilbert Creek	347-06-033	C	6.7	0.3	133.3	6.2	2140.0
Copper Creek	731-04-015	C	246.7	42.0	113.3	19.3	586.7
Loon Creek	509-04-002	C	100.0	7.5	73.3	5.5	1326.7
Helmer Mtn.	119-03-004	C	20.0	1.9	93.3	8.8	1060.0
Five Mile Creek	607-01-061	C	326.7	8.2	246.7	6.2	3960.0
McKillop Road	624-04-005	C	66.7	3.3	73.3	3.7	2006.7
Dead Horse Creek	702-01-003	C	140.0	4.7	173.3	5.8	2993.3
Green Gulch	730-07-001	C	40.0	10.2	53.3	13.6	393.3
First Creek	765-01-018	C	26.7	6.1	33.3	7.6	440.0
Beatrise	831-01-019	C	206.7	10.6	500.0	25.7	1946.7
Big Cedar Creek	716-01-104	C	26.7	10.8	33.3	13.5	246.7
*Big Cedar Creek	716-01-104	C #2	6.7	2.0	26.7	8.2	327
Sunset Creek	743-01-001	C	20.0	4.5	33.3	7.6	440.0
Baptiste	446.06-001	C	233.3	8.2	166.7	5.9	2840.0
Second Creek	764-01-047	C	73.3	15.1	60.0	12.3	486.7
Paul Creek	342-03-007	C	100.0	2.3	166.7	3.9	4326.7
Newport	663-02-002	C	53.3	12.5	40.0	9.4	426.7

*This stand has two control plots and no treatment plot because the stand will not be thinned.

Unit name	Stand no.	Treatment	Species total Infected T/A	Infected %	Mortality T/A	Mortality %	Total T/A
Squaw Valley Flats	848-01-003	T	60.0	5.1	60.0	5.1	1167
West Blacktail	833-03-001	T	46.7	10.0	13.3	3.1	427
Rear High Bridge	847-02-002	T	20.0	0.7	66.7	2.5	2680
Rock Creek	418-04-010	T	40.0	5.4	140.1	18.9	740
Verde Face	379-01-034	T	120.1	6.4	160.1	8.5	1880
Gilbert Creek	347-06-033	T	46.7	1.5	313.5	9.7	3220
Loon Creek	509-04-002	T	53.4	3.8	106.7	7.6	1407
Helmer Mtn.	119-03-004	T	46.7	5.8	33.4	4.1	807
Five Mile Creek	607-01-061	T	213.4	3.2	380.2	5.7	6720
McKillop Road	624-04-005	T	40.0	2.4	100.1	5.9	1700
Dead Horse Creek	702-01-003	T	113.4	4.5	180.1	7.2	2513
Green Gulch	730-07-001	T	46.7	9.9	33.4	7.1	473
Beatrise	831-01-019	T	20.0	5.9	26.7	7.8	340
Swiftwater Creek	702-02-006	T	0	0	20.0	6.8	294
*Swiftwater Creek	702-02-006	T #2	20.0	3.9	20.0	3.9	513.3
Baptiste	446-06-001	T	6.7	1.2	133.4	23.0	580
Second Creek	764-01-047	T	20.0	2.8	80.0	11.0	727
Paul Creek	342-03-007	T	100.1	1.6	286.8	4.7	6133

*This stand has two treatment plots and no control because the stand was thinned before plots were established.