

Root Disease in NSR Lands
in the Southern Interior of British Columbia

FRDA Research Project 3.8
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FOREWORD

This project was funded by the Backlog Reforestation Extension, Research, and Development Programme of the Forest Resources Development Agreement, as research project 3.8. The report by Pathocon Consulting was reproduced verbatim, and is distributed as an unpublished Internal Report by Forest Protection Branch. The purpose is to inform pest management staff, colleagues, and other interested parties of these results. Opinions and recommendations herein are those of the contractors, and are not necessarily those of the Canadian Forestry Service, the B.C. Ministry of Forests and Lands, or members of the FRDA management and technical advisory committees.

The procedures developed in this project were used in 1987 - 1988 in the Merritt Forest District to assess infested stands proposed for harvesting and spacing, and to establish a spacing trial funded under the FRDA pest control programme.

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Summary of FRDA Research Project 3.8 (1986-1987)

Twenty-seven plantations in the Kamloops Forest Region were investigated for the presence of root disease. Eight of these had been designated as not satisfactorily restocked (NSR) at the time of the study. Eighteen cutblocks were studied intensively. This involved observations of root disease indicators in the cutblocks and their adjacent stands and incidence surveys within the cutblocks. The nine remaining plantations were studied without incidence surveys.

Armillaria obscura was found attacking young conifer regeneration and some hardwood species within 14 of the 18 cutblocks studied intensively. Phellinus weirii was found only on one conifer seedling in one cutblock. A. obscura was present in 11 of the 16 adjacent stands examined and P. weirii was present in 5. Douglas fir, Lodgepole pine and White pine were all found to be highly susceptible to attack by A. obscura, both as regeneration and as mature trees in the adjacent stands. Western Larch, Cedar and Hemlock were also found to be susceptible. Of several hardwood species found to be susceptible, Falsebox (Paxistima myrsinites) was the most frequently attacked.

Infected conifer regeneration and hardwood brush species were commonly killed rapidly without prior expression of early symptoms (flash-killed). Thus incidence surveys in young plantations approximated surveys of annual or biennial mortality. A. obscura incidence in plantations less than ten years old ranged from 0 to 15 percent with a mean of 3.2 percent (based on planted trees only). Although root disease losses had not yet caused understocking in these plantations, annual mortality rates of one percent or greater (common in these plantations) pose a significant threat to the stand over a rotation. Plantations older than ten years showed A. obscura incidence levels of 0 to 60 percent. The mean incidence level for these stands was 16.6 percent. The rapid rate of mortality in infected trees in these plantations resulted in understocking and in some cases imminent plantation failure.

Several indicators of root disease in both the cutblock and the adjacent stand were identified. Infected conifer regeneration, residuals and hardwood species (especially Falsebox) were deemed to be the most useful indicators for assessing hazard to A. obscura in the cutblock. Infected trees in the adjacent stand were the most reliable indirect indicators of A. obscura. Infected trees in the adjacent stand and laminar decay in stumps in the cutblock were the only usable indicators of P. weirii. No correlations were noted between ecological association or site features and root disease incidence.

A hazard rating system was developed to assess the risk to both root diseases using root disease indicators. Using this system, the 18 plantations studied intensively were rated as being at high, moderate or low hazard to root disease. Eight plantations were rated high hazard, 3 were rated moderate to high hazard, 3 were at moderate hazard, 1 was at low to moderate hazard and 3 plantations were at low hazard. In the majority of cases, A. obscura was deemed to pose the more serious hazard to the plantation.

From this study it appears that Armillaria root disease is causing severe losses in plantations in the southern interior. Losses become apparent as early as two years after planting and can gradually build up to cause understocking or even plantation failure by age fifteen. Phellinus weirii was not found to contribute appreciably to understocking in the plantations studied.

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1.0 INTRODUCTION

The development of root disease survey methods for stands in the interior of British Columbia has only recently been initiated. It was deemed necessary that survey methods be developed specifically for interior stands as these stands (and thus the appropriate survey procedure) are considerably different in structure and composition from coastal stands. Similarly, survey methods specifically designed for NSR (not satisfactorily restocked) lands were also deemed necessary. FRDA Research Project 3.8 in 1985 to 1986 involved the study of the distribution and symptomology of root disease fungi in multi-aged, mixed species interior stands. This paper is a report of the result of FRDA Project 3.8 1986-1987. It deals with the study of the role and expression of root disease in NSR lands in the ICH (Interior Cedar Hemlock) biogeoclimatic subzone of the Kamloops Forest Region of British Columbia.

Not satisfactorily restocked (NSR) lands have become a major problem of the reforestation program in British Columbia. When regeneration fails to become established, the site is often overtaken by brush species. Once brush has become established on a site, it is very difficult and thus costly to eliminate. There are many possible causes of brushing in, including improper site preparation, planting delay (or absence), and mortality in seedlings due to abiotic or biotic factors. This project concerns itself with a biotic cause of brushing whose full impact is not yet understood.

Root diseases left on the site from the previous rotation of conifers can infect and kill regeneration trees. Due to the method of spread of these diseases, mortality in seedlings is likely to occur in clumps. This can result in areas of hardwood and brush species which will be chronically understocked. The importance of this mechanism of NSR land creation is not clear. However, given our knowledge of the ubiquity and impact of root diseases, it's potential as an NSR agent is very great.

The root disease species present and its habit and vigour may vary with geographical location, site features or stand type. Such variation could lead to variation in the incidence, distribution and/or impact of a given level of infection in preharvest stands and in the subsequent regeneration. Hence it is imperative that the distribution and impact of the diseases in both current and potential NSR lands be studied. With this information survey methods can be developed which will be applicable to the distribution of the disease(s) in the given situation. Such survey methods are required so that hazard can be appraised and control measures implemented.

The objective of this project was the development of a field guide describing methods for the assessment of root

disease incidence and hazard in NSR areas in the southern interior of British Columbia. This report contains a list of the indicators of root disease in young plantations and their adjacent stands and a guide to the assessment of root disease hazard using these indicators. Also included in an Appendix is the biogeoclimatic and pathological data for all the stands and sites studied. Where deemed appropriate, procedures were recommended for control or reduction of root disease fungi on surveyed sites.

2.0 METHODS:

Root disease incidence in a total of 27 NSR and SR cutblocks was studied in the Vernon, Salmon Arm and Kamloops Forest Districts of the Kamloops Forest Region (Figure 1). Most study sites were within the ICHm1 (Thompson R. Moist Central Interior Cedar Hemlock) biogeoclimatic subzone as this subzone had been reported by Ministry personnel as being prone to root disease. Sites in the ICHw (Wet Central Interior Cedar Hemlock) and IDFj1 (Shuswap Highlands Moist Interior Douglas-fir) subzones were also studied upon the recommendation of district Ministry personnel. Eighteen cutblocks were examined thoroughly. The remaining nine were examined less intensively. The blocks were selected from areas which had been denoted as being high in root disease incidence by the R. O. Silvicultures of the Forest Districts. The following was completed on each site examined thoroughly:

A. In the Cutblock:

1. A 3-5% sampling intensity strip survey to determine percent infection by root disease on natural and planted conifers.
2. Examination of hardwoods to determine infection by A. obscura.
3. Mushroom surveys.
4. Examination of on-site debris and stumps.
5. Examination of residual conifers for root disease.

B. In the Adjacent Stand:

Adjacent stands are mature stands adjoining the cutblock or within 250 meters of it, which resemble the stand which occupied the cutblock prior to it being harvested.

Root disease species present (if any) on conifer:

1. Mature timber.
2. Understory species.
3. Standing dead and windfallen timber.
4. Stumps from previous harvests.

C. Ecological information:

For the cutblock and adjoining stand:

Figure 1. Location of Study Sites and Observation Sites.



1. Biogeoclimatic classification to ecological association.
2. Successional status.
3. Conifer species present.
4. Floristic list.
5. Soil classification, drainage, rooting depth, pH.
6. Humus form.

Hardwood tree species present on the site were examined for the presence of Armillaria obscura on their roots and root collar. Armillaria was identified as A. obscura when it appeared to be acting pathogenically or when dichotomous rhizomorphs were present.

3.0 DISEASES STUDIED:

3.1 Armillaria obscura:

A. obscura is a serious forest pest in southern interior forests of British Columbia. It attacks all species of conifers and some hardwood species causing decline and death (Morrison 1981). When examining dead or declining trees suspected of having A. obscura there are several characteristics to look for:

1. Pronounced resin flow at the bole of the tree.
2. Fan-like creamy white mycelium beneath and within the bark of the roots and lower bole.
3. Armillaria mushrooms growing from rotted or mycelium impregnated roots.
4. Black, stringy or root like rhizomorphs attached to the roots.
5. Spongy pocket rot within the roots or butt.

Of these characteristics, the fan-like mycelium and basal resinosis are the most reliable indicators. Armillaria mushrooms and rhizomorphs are produced seasonally and sporadically and are thus not always present.

Hardwood symptomology is similar to that described above except that basal resinosis does not occur. A. obscura spreads by dichotomously branching rhizomorphs through the soil or when a healthy root contacts an infected root, stump or piece of debris. The production of sporophores is prolific yet spread by spores is not fully understood.

3.2 Phellinus weirii (Murr.) Gilb.

P. weirii is also a serious southern interior forest pest. Many species of conifer are attacked but hardwoods are not affected (Wallis 1976). When examining dead or declining conifers for P. weirii the following characteristics should be looked for:

1. White mycelium on the surface of roots.
2. Red staining in the root xylem, often extending into the butt.
3. Laminar decay of the xylem resulting in easily separated, pitted growth rings. The pits are empty or filled with chestnut brown mycelium.
4. Fruiting bodies - these are rarely produced and are not very conspicuous.

The external root mycelium is generally only found on roots within the mineral soil (van der Kamp pers. comm). The mycelium is very thin and very fragile and is thus easily removed if the roots are excavated. In most cases the laminar decay in windthrows and trees broken off at the butt is the most visible symptom. The other symptoms require root excavations or felling of trees and are thus not feasible for use in large surveys except to identify the pathogen present where this is in question. This root pathogen spreads when a healthy root contacts an infected root or stump.

Included in Appendix B is an illustrated guide to the identification of A. obscura and P. weirii.

4.0 CONIFER SPECIES ATTACKED:

Only the conifer species which were attacked on the sites studied are included in this discussion.

4.1 Armillaria obscura

Mature and immature trees of all conifer species present were attacked and killed by A. obscura. Of the mature trees Cedar (Thuja plicata) and Douglas-fir (Pseudotsuga menziesii) were the most frequently attacked species. Infected Lodgepole pine (Pinus contorta var. latifolia), White pine (P. monticola), Hemlock (Tsuga heterophylla) and Larch (Larix occidentalis) were less frequently encountered. However, it cannot be concluded that these species are less susceptible to Armillaria since these species were often less common in the stands studied.

A. obscura was also observed on conifer seedlings as early as one year after they were planted. All conifer species on the site were susceptible at this stage. Douglas-fir and White pine were both highly susceptible on the stands studied.

In some sites the infection rate on White pine was greater than on Douglas fir. This suggests that White pine less than twenty years old is not at all resistant to A. obscura on the study block. Further surveys would be required to determine whether this is the case throughout the Southern Interior. If this is the case, White pine can no longer be suggested as an alternate species for planting in Armillaria

infected areas. Lodgepole pine and Cedar were also found to be quite susceptible to Armillaria. In fact, Western hemlock was the only species which appeared to show any resistance. However, this may have been related to the fact that Hemlock was generally present in the block as very small, natural regen. Such regen could be expected to be less susceptible to root disease than planted stock due to the deformed root stock and stress due to planting involved with the latter.

4.2 Phellinus weirii

Phellinus weirii was observed attacking mature Douglas-fir, Lodgepole pine and Hemlock trees and within Western red cedar stumps. It occurred predominantly on Douglas-fir. P. weirii attack on Lodgepole pine was also fairly common. Immature conifers in the immediate vicinity of infected mature trees were sometimes attacked (and killed) as well.

Only one seedling within the study blocks was found to have been attacked by P. weirii. It was a douglas fir seedling planted in 1982.

5.0 CUTBLOCKS STUDIED:

Appendix A lists the pathological and ecological features of all of the cutblocks studied and their adjacent stands.

Six cutblocks were examined in the Vernon Forest District near Hidden Lake, B.C. (Table 1). The adjacent stands for the blocks were in the ICHm1 subzone (Thompson R. Moist Central Interior Cedar Hemlock), (table 2),, the Pleurozium schreberi - Hylocomium splendens ecological association (IMC). The blocks were logged between 1977 and 1982. Half of the blocks (HIDD-1,5 and 6) were currently rated as NSR-M, the others as fully stocked. With the exception of Hidden Lake Site 4 (HIDD-4), the planted species were attacked by A. obscura. Root disease incidence ranged from 1.4% to 5.6% of the trees on the cutblock. However, these values are very conservative. For the most part they represent mortality which occurred within two years of the survey year. Mortality which had occurred more than two years before the survey was performed was most often unrecognizable in plantations less than five years old. As well, the vast majority of the infected trees were dead. Thus the incidence levels quoted would best be viewed as biennial mortality rates. In this context, these incidence levels may be potentially very damaging if they remain constant until harvest. In two of the three NSR sites (HIDD-1 and HIDD-4), root disease was deemed to be contributing significantly to understocking.

The adjacent stands (Table 2), had Cedar and Hemlock as their main components in all cases. Armillaria obscura was

Table 1

Age and Infection Status of the Hidden Lakes Cutblocks

SITE	DATE EST.	SPP.	ROOT DISEASE			
			<u>A. obscura</u> #INF	#HEAL	%	
=====						
HIDD-1 1980	Cw	2	10	16.7		not present
	Fd*	33	553	5.6		
	Hw	2	58	3.3		
	Lw	1	1	50.0		
	Pw	2	12	14.3		

HIDD-2 1980	Cw	0	8	0.0		not present
	Fd*	9	401	2.2		
	Hw	3	77	3.8		
	Lw	0	30	0.0		
	Pw	0	39	0.0		
	Py	0	4	0.0		
	Sx	0	18	0.0		

HIDD-3 1981	Cw	0	266	0.0		not present
	Fd*	0	199	0.0		
	Hw	0	46	0.0		
	Lw	0	777	0.0		
	Pl	0	3	0.0		
	Pw	0	73	0.0		

HIDD-4 1984	Cw	0	41	0.0		not present
	Fd*	2	55	3.5		
	Hw	0	28	0.0		
	Lw	0	6	0.0		
	Pl*	4	153	2.5		
	Pw	0	2	0.0		

HIDD-5 1981/82	Cw	0	39	0.0		not present
	Fd	0	3	0.0		
	Hw	0	45	0.0		
	Pw*	20	397	4.8		

HIDD-6 1982	Cw	0	3	0.0		not present
	Fd*	9	51	15.0		
	Hw	0	14	0.0		
	Lw	0	63	0.0		
	Pw	9	101	8.2		

* denotes planted species on the block.

Table 2

Composition and Infection Status of the Hidden Lake
Adjacent Stands

SITE	ADJ. STAND	Ecol. Assoc. Present	SPP. Present	ROOT DISEASE A. o.* P.w.*	TYPE OF STAND
HIDD-1	CHBiF 735-P	ICHm1 -1MC	Cw Hw Lw	HIGH HIGH NIL	A
HIDD-2	CHBiF 735-P	ICHm1 -1MC	Cw Hw Lw	HIGH HIGH NIL	A
HIDD-3	CH 836-P and H(C)946-M	ICHm1 -1MC	Cw Fd Hw	MOD NIL	A
HIDD-4	CH 836-P	ICHm1 -1MC	Cw Fd Hw	MOD NIL	A
HIDD-5	HC 86-M	ICHm1 -1MC	Cw Hw Lw	LOW-MOD LOW-MOD NIL	A
HIDD-6	CH 73	ICHm1 -1MC	Cw Fd Hw Lw Pw	LOW-MOD LOW-MOD LOW-MOD NIL	A

* A.o. = A. obscuraP.w. = P. weirii

identified on Cedar in at least one adjacent stand for each block. *A. obscura* was identified on Hemlock in adjacent stands of HIDD-2, 5 and 6 and on Douglas-fir in HIDD-6.

Five blocks were intensively studied in the Barriere area (Table 3). BARR-1, 2 and 4 had adjacent stands in the ICHm1-5 (*Paxistima myrsinites* - *Chimaphila umbellata*) biogeoclimatic ecological association while BARR-3 was in the ICHm1-4 (*Shepherdia canadensis* - *Linnaea borealis*) association. BARR-5 was in the IDFj1-3 (*Symphoricarpos albus* - *Calamagrostis rubescens*) ecological association. The stand history and disease intensity on these sites was fairly heterogenous. *P. weirii* and *A. obscura* were obvious in the adjacent stands of the ICHm1-5 ecological associations. The ICHm1-4 adjacent stand of BARR-3, had *Inonotus tomentosus* and *Phellinus pini* infection. Adjacent stands had a high component of Douglas-fir although none of these stands were of similar composition (Table 4). The percent infection by *A. obscura* varied from 0% to approximately 20% in the blocks studied (Table 3). Site 5 was predominantly a Douglas-fir stand (30% cover) with a smaller component of Lodgepole pine (5%). It had extensive *A. obscura* infection, approximately 60% of the area infected. The risk due to *P. weirii* infected stumps and debris in BARR-2 was unclear. This site had 25% of the stumps infected with *P. weirii* and was planted with White Pine. Thus this site, may be at little or no risk if this tree species is in fact resistant to *P. weirii* (Wallis 1976). However, the White pine on this particular plantation was infected with *A. obscura* (2% incidence). As well, a large proportion of the White pine was infected with *Cronartium ribicola* (White pine blister rust).

The adjacent stands of the Larch Hills sites were ICHm1-5, (Table 5). However, unlike the Barriere sites, no *P. weirii* was found attacking the Douglas-fir in the adjacent stand (table 6). Only about 8% cover of Douglas-fir was noted in LARCH-1 and 10% in LARCH-2. The extent of *A. obscura* infection was confined to a ridge in LARCH-1, 18% in LARCH-2 and 2% in LARCH-3. LARCH-1 was a five year old NSR plantation. This site had been disturbed at some point and currently the disease was appearing on an undisturbed ridge. *A. obscura* was present on many of the stumps in the block. LARCH-2 was a 17 year old plantation and parts of it had been thinned in 1984. *A. obscura* was found attacking Douglas-fir, Spruce, White pine, Lodgepole pine and Cedar on the site to varying degrees (Table 5). The attack had been going on for at least five years and was still causing mortality. *A. obscura* was definitely present and likely was in evidence when the stand was thinned in 1984. In light of this, thinning this site in 1984 was definitely not advisable. LARCH-3 was a two year old 1-0 Lodgepole pine plantation, yet incidence was already 2% current year mortality. The implications of such an annual mortality rate are dire if losses of this magnitude recur throughout the rotation.

Table 3.

Age and Infection Status of the Barriere Cutblocks.

SITE	DATE EST.	SPP	ROOT DISEASES			P. weirii comments
			A. obscura #INF	#HEAL	%	
=====						
BARR-1 DSD		B1	0	78	0.0	residuals infected
		Cw	2	53	3.6	
		Fd	6	163	3.6	
		P1	0	4	0.0	
		Pw	14	88	14.3	
		Sx	0	325	0.0	

BARR-2 1982		B1	0	1	0.0	25% stumps infected
		Cw	0	27	0.0	
		Fd	0	59	0.0	
		P1	0	3	0.0	
		Pw *	8	373	2.1	

BARR-3 1984		B1	0	12	0.0	not observed
		Cw	0	508	0.0	
		Fd *	0	677	0.0	
		P1	0	21	0.0	
		Pw	0	24	0.0	
		Sx	0	15	0.0	

BARR-4 1975		B1	0	8	0.0	not observed
		Cw	0	5	0.0	
		Fd	0	3	0.0	
		P1	0	21	0.0	
		Pw	0	17	0.0	
		Sx *	0	331	0.0	

BARR-5 n/a		Fd	60% of area			not present
		P1	infected			

* denoted planted species in cutblock

SITE	ADJ.	Ecol. SPP.	ROOT DISEASE		TYPE OF
	STND	Assoc. Pres.	<u>A. obscura</u>	<u>P. weirii</u>	STAND
BARR-1	FS	ICHm1	B1		B
	530-M	-5	Cw	HIGH	
			Fd		HIGH
			Hw	MOD	
			P1	MOD	
			Pw		
			Sx	MOD	
BARR-2	F	ICHm1	Cw		B
	430-M	-5	Ep		
			Fd	NIL	HIGH
			Hw		MOD
			Pw		LOW
			Sx		
BARR-3	FS	ICHm1	Cw		B
	530-G	-5	Fd	NIL	NIL
			P1		
			Pw		
BARR-4	FCH	ICHm1	Cw	MOD	B
	831-M	-5	Hw	MOD	MOD
			Pw		
BARR-5		N/A			

Table 6.

Composition and Infection Status of the Larch Hills Adjacent Stands

SITE	ADJ.	Ecol.	SPP.	ROOT DISEASE	STAND
STAND	Assoc.	Pres.	<u>A. obscura</u>	<u>P. weirii</u>	TYPE
LARCH-1	CHF 841-M	ICHm1 -5	Cw Ep Fd Hw Lw Pw Sx	HIGH HIGH	NIL A
LARCH-2	FCS 741-G	ICHm1 -5	Cw Ep Fd Hw Pw	MODERATE	NIL A
LARCH-3	FCS 741-G	ICHm1 -5	Cw Ep Fd Hw Pw	MODERATE	NIL A

One site was studied in the ICHw subzone (Table 7).

This site near Wap Creek was in the ICHw-1 (Gymnocarpium dryopteris - Tiarella unifoliata) ecological association. This was a 15 year plantation and had A. obscura in 4% of the Douglas-fir on site. A. obscura was present in diffuse disease centers which were commonly 15 to 20 m in diameter. Within these centers, A. obscura killed conifers and infected Falsebox and Salix bebbiana were present. Both hardwoods were deemed to be good indicators due to their high susceptibility to A. obscura and their widespread distribution in the stand.

Three sites were studied in Eagle Bay (Table 8).

The adjacent stand type was ICHm1-5 and as in the Barriere sites, in one of these areas there was a high incidence of P. weirii (Table 9). EAGLE-1, a 1985 plantation and EAGLE-2, an NSR-M cutblock had P. weirii infected Douglas-fir stumps throughout the block. As expected no P. weirii mortality was present in the regeneration. EAGLE-3, a 1973 plantation had A. obscura on about 2% of the Douglas-fir. The stand was brushed in 1984 and it looked as if this may have increased the amount of A. obscura on the site. This was evidenced by the fact that many of the brushing stumps had been colonized by A. obscura. A. obscura induced mortality occurred in small centers scattered throughout the block.

The incidence of P. weirii in the ICHm1-5 Barriere and Larch Hills sites but not in the ICHm1-1MC sites near Hidden Lake may be due to a greater component of Douglas-fir in the ICHm1-5 (44% mean cover versus 11% in the ICHm1-1MC of Hidden Lake sites). As Douglas-fir is a highly susceptible host species of this disease, this may explain the high P. weirii incidence in some areas. Where the mature Douglas-fir had been removed (in a selective harvest), typical of the Hidden Lake sites, P. weirii was generally found at low levels or not at all. Hence, cutblocks in ICHm-1 to 5 appear to be at a greater risk to P. weirii than cutblocks in the ICHm1-1MC.

6.0 SITE OBSERVATIONS:

Several sites were observed in a cursory manner (Table 10). The root disease incidence level was determined qualitatively on these sites. Observations were made on three sites within the Vernon Forest District. Two of these areas were within TFL 9 on the west side of Okanagan Lake.

TFL9-a: CP 888, was a stumping trial completed in 1982 with the planting of Lodgepole pine and Douglas-fir. Seventy percent of the area had previously been infected by P. weirii. Part of the site had been stumped, a second part stumped and windrowed and a third area left as a control. The plantation was in excellent health when we viewed it. However, one would not expect P. weirii to be present on regen of such a young age (four years). This was evidenced by the absence of P. weirii symptoms in the control plots. It must be concluded that it is too early as yet to evaluate the efficacy of stumping on this site.

Table 7.

Age and Infection Status of the Wap Creek Cutblock.

SITE	DATE EST.	SPP	ROOT DISEASE			
			<u>A. obscura</u>		<u>P. weirii</u>	comments
			#INF	#HEAL	%	
=====						
WAP-1	1971	Cw	0	9	0.0	none observed
		Fd *	10	239	4.0	
		Hw	0	31	0.0	
		Pw	0	11	0.0	

Compostion and Infection Status of the Wap Creek
Adjacent Stand.

SITE	ADJ.	Ecol.	SPP	ROOT DISEASE	
	STAND	Assoc.	Pres.	<u>A. obscura</u>	<u>P. weirii</u>
=====					
WAP-1	H(C)	ICHw	Cw	NIL	NIL
	831-P	-1	Hw		
			Pw		

Table 8.

Age and Infection Status of the Eagle Bay Outblocks.

SITE	DATE EST.	SPP	A. obscura		ROOT DISEASE %	P. weirii comments
			#INF	#HEAL		
EAGLE-1	1985	Pl *	too young			stumps infected
EAGLE-2	NSR-M		no conifers			stumps infected
EAGLE-3	1973	Cw	0	27	0.0	none observed
		Fd *	6	413	1.5%	
		Hw	0	16	0.0	
		Pw	0	11	0.0	
		Sx	0	25	0.0	

Table 9.

Composition and Infection Status of
the Eagle Bay Adjacent Stands

SITE	ADJ. STAND	E.A.	SPP.	ROOT DISEASE		STAND
				A. obscura	P. weirii	
EAGLE-1	FCHBi (A) 630-M	ICHm1 -5	Cw	NIL		B
			Fd		HIGH	
			Hw			
			Pl		HIGH	
EAGLE-2	FCHBi (A) 630-M	ICHm1 -5	Cw	NIL		B
			Fd		HIGH	
			Hw			
			Pl		HIGH	
EAGLE-3	H 932-P	ICHm1 -5	Cw	NIL	NIL	?
			Fd			
			Hw			
			Sx			

Table 10.

Observation Sites

SITE	TYPE	DATE EST.	LOCATION
=====			
TFL9-a	PL110-M, F110-M	1982	CP888, Siwash Cr. TFL9
TFL9-b	PL110-M	1982	CP883, White Elephant Main, TFL9
HIDD-a	NSM-M R	1981/82	Toledo Jn. Main East of Hidden Lake
BARR-a	S110-G	1978/1984	N. Barriere Lake
BARR-b	F110-M	1984	N. Barriere Lake
BARR-c	F110-G	1985	N. Barriere Lake
BARR-d	NSR-G	n/a	N. Barriere Lake
CICERO-a			Cicero Creek area
LARCH-a	S110-P	1983	Larch Hills
NSR-M	NSM-M	n/a	
	PL110-M	1984	
	F110-M	1982	
=====			

The second area (TFL9-2): CP 882 was also a block within the TFL 9, this was a higher elevation block and had A. obscura infected Lodgepole pine within it. In many cases infected seedlings appeared to be associated with A. obscura infected stumps. Residual trees (Douglas-fir, Cedar, Spruce and Lodgepole pine) within the block were obviously infected with root diseases, subsequently identified as A. obscura and I. tomentosus. The third observation site in the Vernon Forest District was HIDD-a located just down the road from HIDD-5. Although this was essentially the same block as HIDD-5, very few conifers were present here. A. obscura was identified on Falsebox and on some of the few conifers on the block.

Observations were made on four sites in the Barriere Lakes area. The first of these (BARR-a) was a S110-G 1978/1984 plantation on a subhygric site.

No trees were found to have any root disease. Although P. weirii was found across the road from the second observation site (BARR-b)

no sign of root disease could be found in the cutblock itself. This was a 1984 F110-M plantation which was fully stocked. A third observation site, an F110-G 1985 plantation (BARR-c), showed no signs of root disease. However one would not expect A. obscura or P. weirii to show up in such a young plantation. A final NSR-G site was observed (BARR-d), this site had very few conifers on it but A. obscura was present on Falsebox plants on the site.

The Larch Hills had one observation site (LARCH-a).

This was a very large block planted in 1982 to 1984 and also had an area of NSR-M. Spruce, Douglas-fir and Lodgepole pine planted in the block were all free of root disease. The surrounding stands had pronounced P. weirii and some A. obscura in the Douglas-fir.

7.0 ADJACENT STANDS:

The adjacent stands studied were classified into two general stand types.

7.1 Type A stands:

Type A stands were typically decadent Cedar Hemlock timber type. Advance regeneration, typically Hemlock and Cedar was present. Most of these stands had been selectively harvested to remove the Douglas-fir and Larch. This type of stand was typical of the adjacent stands of the Hidden Lake and Larch Hills cutblocks. The Hemlock in these stands was usually heavily infected with heartrot fungi, especially Echinodontium tinctorium and Phellinus pini. The incidence of these decays was often so high that little or no merchantable volume could be expected at harvest. The high incidence of decay was likely attributable in part to the selective

harvest procedures carried out in the past. Hemlock and Cedar were undoubtedly damaged during the falling and yarding of the Douglas-fir and Larch. As wounds to the cambium greater than ten square cm in size provide infection courts for decay fungi (Etheridge and Hunt 1978), it is logical to assume that partial harvesting in these stands had increased the incidence of decays. When stands of similar age which had not been selectively harvested were examined, lower levels of decay were apparent. Lower decay levels were found in the Cedar. However, although conks were infrequent, many Cedar were hollow at breast height. The actual amount of decay in the Cedar was therefore difficult to determine. Extensive decay produced thinned crowns, shortened needles and a lack of smaller branches in infected trees (Figure 2). Eventually top dieback occurred causing spike tops.

A. obscura was present on both Cedar and Hemlock. It was most common on Cedar where it was often found at the root collar. Infection levels in main canopy Cedars sometimes approached 100%. Infected Cedars showed obvious symptoms of decline and were eventually killed (Figure 3). Fewer Hemlock trees were infected but more extensive mycelial fans were present on infected trees (Figure 4). A. obscura was detected in many of the Douglas-fir stumps created by the partial harvest. In many cases A. obscura could not be located due to severe deterioration of the stumps with age. On many of the Douglas-fir stumps and roots the species of Armillaria could not be positively identified. It is possible that A. obscura build up in these stumps was partially responsible for the high incidence of A. obscura on the living Cedar and Hemlock. A description of all adjacent stands of this type and their root disease status is given in tables 2 and 6 and Appendix A.

Generally it appeared that the cause of the decadence of these stands was mainly or entirely pathological (decay and root disease). In many cases it appeared that the poor condition of these stands was at least partially due to selective cutting of the stands in the past.

7.2 Type B stands:

Type B stands were composed of Douglas-fir, Cedar, Lodgepole pine, Hemlock and Interior spruce. They occurred adjacent to sites BARR-1, 2 and 4 and EAGLE-1 and 2. These stands had generally not been selectively harvested in the past. Decay was uncommon. However, root diseases were quite common. A. obscura occurred on all conifer species present. As well, P. weirii, rare or absent in type A stands, was common on Douglas-fir in type B plots. The difference in P. weirii incidence may have been due to the presence of Douglas-fir in type B stands.



Figure 2.

Hemlock severely infected with Echinodontium tinctorium heartrot. Cedars showing symptoms of A. obscura infection.



Figure 3.

Western hemlock and Cedar infected with decay fungi and A. obscura. Note rounded crowns of root diseased Cedars.

Figure 4. (right)
Mycelial fans of A. obscura
growing on the bole of a
Western hemlock.



Figure 5.
Infection center near Barriere B.C. This center was formed
by P. weirii and A. obscura and was many hectares in size.

P. weirii was found to occur in classical or diffuse infection centers or as single tree infections. A. obscura and P. weirii often occurred together in infection centers as a complex. Such centers contained hardwoods and advance conifer regeneration. These hardwoods served as excellent indicators of root disease centers when the surveys were performed in the fall. The hardwoods changed into their fall colors, resulting in distinct bright yellow areas which could easily be picked out from a distance (Figure 5). The presence of dead and dying conifers within these patches indicated that a root disease was indeed present (Figure 6). Examination of four such centers, identified from a distance, resulted in confirmation of the presence of P. weirii and A. obscura in every case. Also, in every case the surveyors were confident that the diseases were causal agents of these hardwood patches. Thus, these patches (appropriately examined) could be used as root disease hazard indicators prior to harvest. The presence of clumps of large hardwoods or hardwood debris could be used as indicators of root disease hazard in post harvest assessments.

Tables 4 and 9 summarize the adjacent stands of this type. Further information on both types of adjacent stands is presented in Appendix A.

B.0 CORRELATION OF ROOT DISEASE WITH SITE FEATURES:

Various ecological features were studied to determine whether root disease incidence was correlated to site features. However, no trends were discovered. Soil features, such as soil type, pH, drainage, texture, humus, soil nutrient regime and soil moisture regime varied from site to site but did not appear to affect root disease infection levels (Tables 11 and 13). Site features such as drainage and rooting depth also did not appear to have any effect on infection levels. Adjacent stand type, however, did correlate to some extent. Where the stand studied was similar to the previous stand in the block, the amount of disease in the stand was similar to the amount of disease present in the block (Tables 12 and 14). The correlation between the presence of P. weirii in the adjacent stand and its presence as indicated by stumps on the block was fairly good for the ICHm1-5. These were also inventoried as having Douglas-fir as a major stand component.



Figure 6.
Enlarged view of the infection center in Figure 5.
Dead and declining conifers (indicative of the presence
of a root disease) can be distinguished.



Table 11.

Soil Features and Root Disease Incidence For All Outblocks

SITE	DISEASE INCIDENCE		SOIL TYPE	HUMUS	SMR	SNR	TEXT.	pH
	A.o. (%)	P.w.* (%)						
=====								
HIDD-1	5.6	NIL	EEB	NEG	M	C-D	SiL	7.0
HIDD-2	2.2		EEB	NEG	M	C-D	SiL	7.0
HIDD-3	0.0		EDB	NEG	M-SM	D-E	Si	7.5
HIDD-4	3.0		EDB	NEG	M-SM	D-E	Si	7.5
HIDD-5	4.8		EDB	RHIZO- MULL	M- SHG	C-D	Si	6.0
HIDD-6	15.0		EDB	MODER	M	C-D	SiL	6.0

BARR-1	3.5	Resid.	OHG	MULL- MODER	M- SHG	D-E	SiCL	7.0
BARR-2	2.1	STUMPS	EDB	RHIZO- MULL	SM	C-D	SL	7.0
BARR-3	0.0	NIL	EDB	NEG.	SM	B-C	SCL	6.0
BARR-4	0.0	NIL	OHP	NEG.	M	B-C	LS	6.0
BARR-5	60%	NIL area	ODB	LEPTO- MODER	SM	B-C	SiL	6.0

LARCH-1	0.0	NIL	EEB	NEG.	M	D	SiCL	7.5
LARCH-2	14.8	NIL	EDB	NEG.	SX, SM, SHG	B-C, C, C-D	SiCL, L	6.0, 7.0
LARCH-3	2.0	NIL	EEB	NEG.	SX	C	SL	7.0

WAP-1	4.0	NIL	OHP	NEG.	M	B-C	L	4.5

EAGLE-1	0.0	STUMPS	EEB	NEG.	M	C-D	SiL	6.5
EAGLE-2	0.0	STUMPS	EEB	NEG.	M	C-D	SiL	6.5
EAGLE-3	1.5	NIL	EEB	NEG.	M	C-D	SiL	6.5

* A.o. = A. obscura, P.w. = P. weirii

Soil Types:

EEB - Eluviated Eutric Brunisol
 EDB - Eluviated Dystric Brunisol
 OEB - Orthic Eutric Brunisol
 OHP - Orthic Humoferric Podzol

Humus: Neg. = Negligible

Disease incidence is the percent infected for planted species. In naturally regenerated sites, it is the percent infected of the two or three most common species.

Table 12.

Ecological Features and Disease Incidence for All
Cutblocks

SITE	DISEASE INCIDENCE		CONIFERS PRESENT	DRAINAGE	ROOT. DEPTH (cm)	EXPOS.	ASPECT
	A.o.	P.w.					
HIDD-1	5.6	0.0	Cw,Fd*,Hw, Lw,Pw	MOD.	15	N/A	N/A
HIDD-2	2.2	0.0	Cw,Fd*,Hw, Lw,P1,Pw, Py,Sx	MOD.	15	N/A	N/A
HIDD-3	0.0	0.0	Cw,Fd*,Hw*, Lw,P1,Pw	WELL	15	MOD.	S.
HIDD-4	3.0	0.0	Cw,Fd*,Hw Lw,P1*,Pw	WELL	15	MOD	S
HIDD-5	4.0	0.0	Cw,Fw,Hw Pw*	MOD-	8	N/A IMP.	N/A
HIDD-6	15.0	0.0	Cw,Fd* Hw,Lw,Pw	MOD.	25	N/A	N/A
BARR-1	3.5	Resids	Cw,Fd,Pw Se	IMP.	20	N/A	S
BARR-2	2.1	Stumps	B1,Cw,Fd P1,Pw*	WELL	15	MOD- HIGH	S
BARR-3	0.0	0.0	B1,Fd* P1,Pw,Se	WELL	>30	MOD- HIGH	S
BARR-4	0.0	0.0	B1,Cw,Fd P1,Pw,Sx*	WELL	15	MOD	S
BARR-5	60%	0.0	Fd*,P1*	WELL	20	N/A	N/A
LARCH-1	0.0	0.0	B1,Cw,Fd* Hw,Lw*,Pw,Sx	MOD.	15	MOD.	N
LARCH-2	14.8	0	Cw,Fd*,Hw P1,Pw,Sx*	IMP.- V.WELL	25	MOD.- HIGH	N
LARCH-3	2.0	0.0	P1*,Sx*	WELL	15	MOD.- HIGH	N
WAP-1	4.0	0.0	Cw,Fd*, Hw,Pw	VERY WELL	20	N/A	N/A
EAGLE-1	0.	Stumps	P1*	MOD.	15	MOD	N
EAGLE-2	0.	Stumps		MOD.	15	MOD.	N
EAGLE-3	1.5	Stmps	Cw,Fd* Hw,Pw,Sx	MOD.	15	LOW	S

* Indicates species planted on the site.

1 Species are listed in alphabetical order.

2 N/A=Not Applicable. Applies when slope was approx. zero.

Table 13

Root Disease Incidence and Soil Features
in Adjacent Stands

SITE	DISEASES PRESENT*	SOIL TYPE	HUMUS	SMR	SNR	TEXT.	pH
=====							
HIDD-1	A.o.	EEB	HEMIMOR	M	C-D	SiL	7.0
HIDD-2	A.o.	EEB	HEMIMOR	M	C-D	SiL	7.0
HIDD-3	A.o.	EDB	HEMIMOR	M-SM	C-D	SiL	6.0
HIDD-4	A.o.	EDB	HEMIMOR	M-SM	C-D	SiL	6.0
HIDD-5	A.o.	EDB	HEMI- HUMIMOR	M- SHG	B-C	Si	6.0
HIDD-6	A.o.	EDB	HEMIMOR	M	B-C	SiL-L	6.0
BARR-1	A.o., P.w.	OEB	LEPTO- MODER	SM-M	C-D	SL	7.0
BARR-2	P.w.	EDB	LEPTO- MODER	M	B-C	SL	5.5
BARR-3	None	EDB	LEPTO- MODER	SM	B-C	SL	6.0
BARR-4	A.o., P.w.	OHP	MOR- MODER	M	C-D	SiL	7.0
BARR-5		N/A					
LARCH-1	A.o.	EEB	LEPTO- MODER	M	C-D	L	7.0
LARCH-2	A.o.	EDB	MOR- MODER	M	C-D	SiL	7.0
LARCH-3	A.o.	EEB	MOR- MODER	M	C-D	SiL	7.0
WAP-1	None	OHP	HEMIMOR	M	B-C	SL	4.5
EAGLE-1	P.w.	EEB	MORMODER	M	C-D	SiL	6.5
EAGLE-2	P.w.	EEB	MORMODER	M	C-D	SiL	6.5
EAGLE-3	None	EEB	MORMODER	M	C-D	SiL	6.5

A.o. = Armillaria obscura.

P.w. = Phellinus weirii.

Soil types:

EEB - Eluviated Eutric Brunisol

EDB - Eutric Dystric Brunisol

OEB - Orthic Eutric Brunisol

OHP - Orthic Hemiferric Podzol

Humus:

Neg. = negligible

Table 14

Root Disease Incidence and Ecological Features
in Adjacent Stands

SITE	DISEASES PRESENT	CONIFER PRESENT	DRAINAGE	ROOT. DEPTH (CM)	E.A.	ASPECT
=====						
HIDD-1	A.o.	Cw,Hw	MODERATE	15	ICHm1 -1MC	N/A
HIDD-2	A.o.	Cw,Hw	MODERATE	15	ICHm1 -1MC	N/A
HIDD-3	A.o.	Cw,Fd Hw	WELL	15	ICHm1 -1MC	S
HIDD-4	A.o.	Cw,Fd Hw	WELL	15	ICHm1 -1MC	S
HIDD-5	A.o.	Cw,Hw Lw	MODERATE -IMPERF.	>20	ICHm1 -1MC	N/A
HIDD-6	A.o.	Cw,Fd Hw,Lw,Pw	MODERATE	25	ICHm1 -1MC	N/A
BARR-1	A.o,P.w.	Bl,Cw,Fd Hw,Pw,Sx	WELL	>25	ICHm1 -5	S
BARR-2	P.w.	Cw,Fd Ep,Pw,Sx	WELL	20	ICHm1 -5	S
BARR-3	None	Cw,Fd Pl,Pw	WELL	>30	ICHm1 -4	S
BARR-4	A.o.	Cw,Fw Hw,Pw	MODERATE	>25	ICHm1 -5	S
BARR-5	N/A					
LARCH-1	A.o.	Cw,Ep, Fd,Hw,Lw Pw,Sx	MODERATE	>25	ICHm1 -5	N
LARCH-2	A.o.	Cw,Ew Fd,Hw,Pw	WELL	>20	ICHm1 -5	N
LARCH-3	A.o.	Cw,Ep Fd,Hw,Pw	WELL	>20	ICHm1 -5	N ICHm1
WAP-1	None	Cw,Hw Pw	VERY WELL	>25	ICHW1 -5	N/A
EAGLE-1	P.w.	Cw,Fd Hw,Pl	WELL	20	ICHm1 -5	S
EAGLE-2	P.w.	Cw,Fd Hw,Pl	WELL	20	ICHm1 -5	N
EAGLE-3	None	Cw,Fd Hw,Sx	WELL	25	ICHm1 -5	N

9.0 ROOT DISEASE HAZARD INDICATORS

9.1 Conifer Regeneration and Residuals:

When a cutblock contains conifer regeneration (natural or planted), a regeneration survey for A. obscura can be carried out. Dead or declining trees are examined for the presence of A. obscura mycelial fans on their root systems. A. obscura can be distinguished from A. type 5 (a saprophytic species), by: dichotomously branched rhizomorphs and mycelial fans acting pathogenically (attacking the tree when it is alive and penetrating the phloem) in the former. In the cutblocks studied in this project, A. obscura commonly expressed itself in the conifer regeneration. This was true even in two year old plantations. Surveys of this kind are particularly useful as they yield direct evidence of impact on the site. This impact can be extrapolated to a hazard rating with more confidence than indirect methods (those not involving crop trees on site). This indicator can only be used on sites which have conifer regeneration present. Also, regen surveys of young plantations can only assess mortality for the past two to three years. Since evidence of earlier mortality is often lacking, or where cumulative mortality over a number of years is to be measured, certain hardwood species can be included in the survey (see 9.2 Hardwood Indicators).

Where little regeneration is present on the cutblock, residual conifers can be examined for the presence of A. obscura. However, as such trees are generally quite sparse and unevenly distributed in the block, they are not appropriate for quantitative incidence estimates.

P. weirii did not commonly manifest itself in trees under three meters tall in this study. For this reason, the use of this sort of survey is only recommended for older plantations or younger cutblocks with a lot of residuals present. Declining and dead trees (within the strip) should be examined for white surface mycelium on the roots, red staining in the xylem and laminar decay of the xylem. The typical above ground symptoms of root disease in young conifers are present in P. weirii infected trees. These include stress crops of cones, crown thinning, crown rounding and mortality.

9.2 Hardwood Indicators:

A. obscura was found attacking twelve different hardwood species. Table 15 lists these species, the number of sites where A. obscura was found attacking the species and the Ecological Association each species was found in. Paxistima myrsinites (Falsebox) was found to be the best hardwood indicator of A. obscura in the blocks studied. On hardwoods A. obscura can be identified using the same symptoms as for conifer regeneration. Mycelial fans below the bark at the

root collar and dichotomous rhizomorphs are indicators of A. obscura on a plant. However, basal resinosis does not occur on hardwoods.

The features which make Falsebox suitable for use in A. obscura incidence surveys are:

1. A high susceptibility to A. obscura (similar to that of Douglas-fir).
2. Similar infection levels to those in young conifers on the site.
3. High density and widespread distribution through most cutblocks it was found in.
4. Widespread geographic distribution within a wide variety of ecological associations of several biogeoclimatic subzones.
5. Even small plants are susceptible due to presence of a large tap root.

Falsebox is found in the following Ecological Associations:

IDFj1:	1MS, 1MC, 1YS, 2, 3, 4, 5
ICHe1:	1, 2, 3, 4, 5, 6
ICHm1:	1MC, 1YC, 2, 3, 4, 5, 6, 7
ICHw:	1, 2, 3, 4, 5, 6

The above ground syptomology expressed by Falsebox varies depending on the pattern of A. obscura invasion of the roots. Where A. obscura has girdled the root below the point at which all the aerial shoots diverge from the tap root the whole plant will be chlorotic or dead (depending on how long ago girdling occurred) (Figure 7 and 9). Where sections of the root collar have been girdled, or where invasion has occurred above the divergence point of the shoots, portions of the plant will have died off. This results in individual plants bearing healthy and chlorotic or dead branches at the same time (Figure 8). Care must be taken to ensure that root disease symptoms are not confused with dieback due to other causes. Dieback is common in Falsebox. It can be distinguished from root disease by the fact that dieback often kills only portions of individual shoots. This is generally not the case with A. obscura.

Hence, although hardwood infection by A. obscura is not a direct measure of A. obscura infection on conifers, due to its high susceptibility, Falsebox infection closely resembles what would be present if conifers were present. A record of infections in hardwoods is also present as these species may be acting as bridging agents for A. obscura. This may involve bridging between conifer species (physical bridging) or sustaining the pathogen in the absence of conifers (temporal bridging). Hardwood indicators are most important when no conifer regeneration is present in the block.



Figure 7.
Falsebox plant killed by A. obscura. The Douglas-fir
behind it was heavily girdled by the fungus.



Figure 8.
Chlorosis in Falsebox caused by A. obscura.
Note the presence of healthy shoots.

Table 15:

Hardwoods affected by A. obscura.

Hardwood species *	Ecological Associations	No. Sites.
<u>Paxistima myrsinites</u>	ICHm1-1MC, 5; ICHw-1	11
<u>Shepherdia canadensis</u>	ICHm1-1MC, 5; IDFj1-3	3
<u>Populus balsamifera</u>		
ssp. <u>trichocarpa</u>	ICHm1-1MC	1
<u>Lonicera utahensis</u>	ICHm1-1MC	1
<u>Vaccinium membranaceum</u>	ICHm1-1MC	1
<u>Betula papyrifera</u>	ICHm1-1MC	1
<u>Ceanothus sanguineus</u>	IDFj1-3	1
<u>Amelanchier alnifolia</u>	IDFj1-3	1
<u>Rosa gymnocarpa</u>	IDFj1-3	1
<u>Salix bebbiana</u>	ICHw-1	1
<u>Alnus viridus</u> ssp. <u>sinuata</u>		1
<u>Spirea betuifolia</u>	ICHm1-1MC	1

* Above ground symptoms of root disease in these species is illustrated in Appendix B.

Root disease surveys using only Falsebox (greater than 30 cm high) were conducted on three sites in the Hidden Lake and Larch Hills areas. The results of these surveys when compared to surveys of the same area using only conifers are presented in Table 16. As can be seen the estimates obtained using Falsebox were reasonably close to those obtained by the conifer survey. A benefit of the hardwood survey over a conifer survey is that it can assess disease incidence in clearings which do not contain conifer species. The main disadvantage with the Falsebox survey was that it was labour intensive since root excavations of most infected plants were required for confirmation of disease presence. The optimum survey method was deemed to be a combination of the two methods. It would consist of surveying conifers for infection where such trees are present and surveying Falsebox in open areas where conifers are absent.

9.3 Stumps and Debris:

Where stumps remain intact within the cutblock, a survey of root disease in the stumps can be used to estimate hazard. Sites which have been lightly burned may be surveyed in this manner provided that the bark remains on the stump. A stump survey entails examination of stumps of all species for evidence of Armillaria or P. weirii infection. The presence of P. weirii is evidenced by laminar decay within the roots and/or stump. A. obscura is detected as mycelial fans beneath and within the bark of the roots and stump. While this method is relatively easy, it can be time consuming when surveying for Armillaria. The species of Armillaria cannot easily be determined with this method. This is important as the species of Armillaria common in the area (A. obscura and Armillaria type V) vary greatly in pathogenicity. A. obscura is pathogenic and it's incidence is thus important in assessing root disease hazard on the site. Armillaria type V is mainly saprophytic and therefore does not pose a hazard. A further disadvantage with this system is that while it gives an estimate of disease incidence at the time of harvest (plus subsequent colonization of stumps) it does not give a direct indication of losses which can be expected in the subsequent stand.

However, if no conifers or hardwoods (of susceptible species) are present on the site, this is the only method which can provide a qualitative measure of root disease on the site. Thus, assessments of Armillaria hazard made immediately after harvest must utilize stumps for on site observations.

The presence of laminar decay in the bole of an infected tree, however, represents an advanced stage of the disease. Thus surveys of visibly decayed stumps are likely to underestimate the incidence of the disease. Merler, (Pers. Comm.) has reported that a post-harvest stump survey detected

Table 16.

Comparison of Conifer and Hardwood A. obscura Surveys.

Site	Falsebox density (N/ha)	% Falsebox with <u>A. obscura</u>	% Conifers infected			
			mean (all spp)	mean (inf. spp)	by spp	
HIDD-6	2733	5.2	2.2	4.9	Pw	8.2
					Fd	1.5
LARCH-1	2175	0.0	0.0	0.0		
LARCH-2	3307	12.3	14.4	19.3	Cw	11.0
					Fd	14.8
					Pw	22.2
					Sx	29.3



Figure 9.
A. obscura mushrooms growing on the roots of a
falsebox plant.



Figure 10.
Laminated brown pitted rot characteristic of P. weirii.

only 30% of the trees diagnosed as infected before harvest. For this reason P. weirii incidence estimates from stump surveys must be viewed as conservative with regard to disease incidence at the time of the survey. Stump surveys for P. weirii are especially useful since direct assessment for hazard (regeneration surveys) cannot be performed in young plantations.

9.4 Sporophores:

Armillaria infections often produce vast quantities of sporophores in the fall (Figures 11 and 12). A sporophore survey can be completed by walking through the block observing the occurrence of Armillaria sporophores and the substrate they are growing out of. Sporophores on living conifers or hardwoods would be of A. obscura while those found growing out of pieces of wood, dead trees or stumps could be either A. obscura or Armillaria type V. The presence of sporophores on these latter substrates cannot be extrapolated to a hazard rating. As well, those occurring on living substrates do so sporadically. Observations in the field revealed many instances where two equally A. obscura infected trees positioned within two meters of each other had mushrooms present on only one of the trees. Also, mushrooms appear in the fall at different times each year depending on climatic factors. Thus the seasonal window during which surveys could be performed is fairly narrow and difficult to predict. Sporophores are useful for confirming the presence of A. obscura on individual declining conifers and hardwoods. They cannot be used as a positive indicator of A. obscura on dead plants unless the root collar is examined to determine whether the mycelium present was acting in a pathogenic mode. The uncertainties in determining Armillaria species and extrapolating mushroom incidence to root disease incidence, along with the seasonal nature in hazard assessment, makes these surveys of little use in hazard assessment. R. weirii sporophores are rarely produced and can be quite inconspicuous. Thus sporophore surveys are not recommended for hazard assessment (for A. obscura and P. weirii).

9.5 Observations in Adjacent Stands:

The premise on which this is based is that root disease conditions in the cut-block prior to harvest are mirrored by root disease conditions in adjacent stands. Adjacent stands are the stands surrounding a cutblock, within 250 meters of each edge. Generally the one(s) closest to the cutblock are the most useful. Surveys are performed in the adjacent stand which most closely resembles that which previously occupied the cutblock. Factors such as stand age, slope, stand species composition and stand history must be considered in choosing the suitable stand.



Figure 11. Sporophores of A. obscura.



Figure 12.
A. obscura sporophores growing on the roots of a hardwood.

The 50 to 100 m of the stand adjoining the cutblock should be examined via a walk through for signs of root disease. The root collar and lower portion of the bole of dead and declining trees should be examined below the bark for signs of A. obscura mycelial fans and dichotomous rhizomorphs. Windfalls, declining trees and dead trees should be examined for P. weirii signs. These include white ectotrophic mycelium on the roots below the mineral soil, red stained xylem and laminar decay. Stumps from partial harvest, if present, in the adjacent stand should also be examined for root disease. previous

This method cannot be used alone to assess root disease hazard in the cutblock reliably. This is due to the fact that root disease distribution is not necessarily correlated with the site features used to select adjacent stands. Thus there may be large differences between the root disease incidence within the cutblock and in the adjacent stand selected.

A great deal of variation was found to occur between adjacent stands surrounding a single cutblock, even when all were of similar stand type, slope etc. In some cases one of the four adjacent stands (north, south, east or west) had 0% disease incidence while another was over 20%. Clearly in such cases the choice of the correct adjacent stand to use for the hazard assessment is crucial. However, as there is often no logical method of choosing the best stand, it is recommended that at least three adjacent stands (if present) be examined.

Adjacent stand examination will not yield a reliable estimate of how much root disease can be expected on the block. Observations in adjacent stands will yield information regarding the potential expression of root disease in the area. If such observations are coupled with observations within the cutblocks, a useful hazard assessment can be obtained which will be more accurate and yield more information than either single assessment method alone.

10.0 SUMMARY OF HAZARD INDICATORS:

10.1 Regeneration and Residuals:

Advantages:

- good for A. obscura assessment of all ages
- gives good estimates for past two years mortality
- can be used on young plantations and for residuals of NSR areas
- can be used for P. weirii older plantations

Disadvantages:

- only suitable for older P. weirii plantations
- requires conifers on site
- residuals are usually fairly scarce and unevenly distributed

10.2 Hardwoods:

Advantage:

- provides a good estimate of amount of A. obscura present when no conifer regeneration is present

Disadvantages:

- cannot be used for P. weirii infection
- requires examination of plant roots for positive identification of A. obscura

10.3 Stumps and Debris:

Advantages:

- are quite quick depending on how deep the roots are searched
- can be used where no other evidence exists
- are often the only indicator for P. weirii infection available on the cutblock

Disadvantages:

- does not detect Armillaria to species
- not extrapolatable to expected incidence
- tends to yield conservative estimates
- not possible when stumps have been disturbed

10.4 Sporophores:

Advantages:

- very quick method
- can be used to confirm A. obscura on declining hardwoods and conifers

Disadvantage:

- can only be used for Armillaria
- does not detect species of Armillaria
- seasonal and sporadic
- does not extrapolate to hazard

10.5 Observations in Adjacent Stands:

Advantages:

- provides a good idea of whether a threat due to P. weirii may exist on the block
- may be used where the cutblock has recently been burned

Disadvantages:

- can be variable depending on which adjacent stand is examined
- disease occurrence in stand is not necessarily extrapolatable to hazard in the block

Based on these advantages and disadvantages, the effectiveness of each hazard indicator as a method for hazard assessment of cutblocks was evaluated. The results of these evaluations are presented in Table 17. Each method was rated on its suitability for evaluating root disease hazard at the pre-harvest, post harvest (pre-site establishment) and post site establishment stages. The ratings given are; good (G), fair (F), poor (P) and inapplicable (-). Assignment of a rank other than '-' assumes the presence of the indicator on the site. As can be seen, conifer regen and hardwoods on the site were the best indicators of A. obscura. Stumps were the best indicators of P. weirii.

11.0 HAZARD ASSESSMENT:

The objective of root disease hazard assessment is to provide information which will allow the manager to minimize losses to root disease. Potential losses include not only timber volume but also money spent on silvicultural practices on sites where root disease eliminates the expected gains from these procedures. It is essential to know the risk of incurring root disease losses before such procedures are implemented. Hazard assessment prior to planting may also allow reduction of future losses by planting resistant species.

Assessment of hazard is in essence an attempt to predict the future. As with all such attempts there is an uncertainty factor. In root disease hazard assessment this factor has to do with the behaviour of the disease (with regard to spread and intensification rate) over time. There is very little information regarding the behaviour of A. obscura and P. weirii in the central interior. Therefore the uncertainty factor associated with our assessments of hazard is substantial.

For P. weirii the assessment of risk is dependant on the occurrence of P. weirii in adjacent stands or evident in the block. The frequency of stumps within the block is very important. For A. obscura, risk is a function of plantation age, the amount of infection in the cutblock and expected rotation age.

11.1 RECOMMENDED METHOD FOR HAZARD ASSESSMENT:

It is recommended that root disease hazard assessments be made using both adjacent stand and cutblock observations. The use of adjacent stands may be replaced by on the block observations (stump surveys) where the block has not been burned. Also, where adjacent stands (of similar type to that of the cutblock prior to harvest) do not exist P. weirii incidence must be evaluated using stumps or debris on the cutblock. The procedures to be followed are outlined below.

Table 17.
Suitability of Hazard Indicators in Hazard Rating
Cutblocks For A. obscura and P. weirii.

Survey method	AGE of STAND		
	Pre-harvest	Post harvest	Post establish.
for <u>A. obscura</u> :			
sporophores	P	P	P
regeneration	-	G	G
hardwoods	P	F	G
residuals	-	P	P
stumps	F	F	P
for <u>P. weirii</u> :			
stumps	G	G	G
windfall, debris			
residuals	-	P	P
regeneration	-	-	P *

Ratings other than '-' assume the presence of the indicators (ie. intact stumps).

* At ages studied (< 20 years)

11.1.1 Assessment in adjacent stands

Where possible examine stands adjacent to the cutblock of interest:

1. Estimate P. weirii presence using above ground symptoms, include infected and broken off stumps and windfalls in estimate.
2. Where such exist (as in partially cut stands), examine cut stumps for the presence of A. obscura mycelium and rhizomorphs.
3. Inspect clearings and dead or declining trees (conifers or hardwoods) for the presence of A. obscura.

Risk to P. weirii on the site is proportionate to the proportion of stumps infected within the cutblock or the incidence level in the adjacent stands. Incidence estimates within the cutblock should be used in preference to adjacent stand estimates.

As only qualitative estimates of hazard can be made, only qualitative estimates of incidence in the adjacent stand should be attempted. The 100 meter wide strip of the stand nearest to the cutblock should be examined via a walk through for stumps or windfalls with laminated decay typical of P. weirii. If P. weirii is present and appears to be fairly widespread in any of the adjacent stands, the cutblock should be assessed as being at risk to P. weirii in the future. The presence of P. weirii should be confirmed if possible on the cutblock before the risk is confirmed. Assessment of the level of risk should be made using data from examination within the cutblock.

Examinations of clearings and declining or dead trees for A. obscura should be performed concurrently with those for P. weirii. Where stumps from previous partial cuts are present, these too should be investigated. Investigation for A. obscura involves checking beneath the bark at the base of the stump for A. obscura mycelium or rhizomorphs. Incidence of A. obscura as a pathogen (causing decline or mortality) indicates risk of A. obscura losses within the cutblock. Assessment of level of risk should then be made using data from surveys within the cutblock.

11.1.2 Assessments within the cutblock:

1. Assess the presence of A. obscura and P. weirii on residual conifers and hardwoods.
2. Assess the proportion of conifer stumps on site with P. weirii decay.
3. Assess the incidence level of A. obscura in conifer regeneration and hardwood species on site.

Assessments of hazard can be made within the block except where the cutblock has very recently been cut and burned. The hazard to both P. weirii and A. obscura should be assessed. The presence of root disease within the cutblock can often be detected using symptomatic residuals on site. As well, patches of hardwoods or hardwood debris should be examined for root disease. These observations can be made during the initial walk through.

P. weirii:

The presence of P. weirii can best be detected where stumps are present and intact. The stumps can be surveyed to obtain quantitative estimates. Where intact stumps do not exist, P. weirii decayed debris can be used. However, a quantitative estimate cannot be obtained using debris. As well, clumps of large standing hardwoods or patches of hardwood logs and stumps remaining from such clumps should be examined for signs of A. obscura and P. weirii infection. As well, the conifers in the immediate area should be examined for root disease infection.

Qualitative assessments should be made during the initial walk through. The quantitative estimates are obtained using a survey. The survey method for P. weirii involves tallying the number of infected and healthy stumps within a series of narrow strips laid out along a 100 m flexible grid. Such a survey requires that stumps are intact and unburned. This survey should be incorporated into the survey for A. obscura and should be performed in conjunction with the survey of regeneration and hardwoods for A. obscura.

A. obscura:

Assessments for A. obscura on the cutblock should take the form of a survey of conifer regeneration and hardwood species for above ground symptoms. The symptoms used are described in the field guide (Appendix B). The survey method to be used involves a 5 m wide strip survey laid out on the block on a 100 m by 100 m flexible grid. The sampling intensity of the survey should be approximately 5%. Tallies of infected trees and infection centers are taken. Detailed methods for this survey are found in Appendix B.

Occurrence of either disease in the adjacent stand indicates risk to the cutblock. The degree of risk can be quantified using the incidence estimates derived from the regeneration and stump survey. However, these hazard assessments are somewhat subjective since the behaviour of A. obscura and P. weirii over time has not been studied in the interior of British Columbia.

The presence or absence of each of the diseases in the adjacent stands and in the cutblock should be reported along with quantitative estimates of disease incidence from surveys (if performed) to the regional pathologist for assessment of

root disease hazard on the site and recommendations for treatment of the site.

11.2 Hazard Assessment of Study Sites.

Root disease hazard assessment for P. weirii and A. obscura was attempted for each site studied. The results of this are found in Table 18. Hazard was assessed as high, moderate or low. These hazard levels represent the estimated risk of incurring serious losses to root disease in the cutblock. A. obscura hazard levels were based on the incidence of the disease and the age of the plantation. High root disease incidence in a young stand represents high hazard to the site. This assumes that such incidence levels will remain fairly constant or will increase over the next several years. Discussions of how each hazard assessment was determined and recommended site treatments are presented in the individual site descriptions (Appendix A).

12.0 Treatment Options:

Our ability to formulate appropriate treatment recommendations for root disease infected NSR sites is strongly limited by the lack of existing data concerning the behaviour of A. obscura and P. weirii in young, interior stands. We are unable to predict with confidence the impact which can be expected at rotation given a certain incidence of A. obscura at an early age. As well, we do not know if P. weirii conditions in adjacent stands (or in stumps on the cutblock) reflect incidence levels which can be expected within the stand at rotation age. The treatment options presented below are accordingly conservative in nature. More drastic and expensive measures should not be implemented on a large scale without concrete evidence regarding the expected losses with and without treatment.

The appropriate treatment recommendation depends on the characteristics of the site, the disease present and the hazard level. Generally no treatment (for root disease) is required where hazard has been assessed as low. Given a moderate or high root disease hazard assessment, special treatment of the block should be considered. A list of recommended procedures for moderate to high hazard cutblocks is listed in Table 19. Please note that planting with conifer species which are 'resistant' to A. obscura is not recommended. This is due to the fact that seedlings of such conifer species were found to be quite susceptible to A. obscura. While no resistant species are recommended, planting of Douglas-fir is not recommended in root disease infected cutblocks as this species appeared to be the most susceptible to both A. obscura and P. weirii.

Table 18

Root Disease Hazard Assessment for the Cutblocks Surveyed

SITE	<u>A. obscura</u>	<u>P. weirii</u>
HIDD-1	HIGH	LOW
HIDD-2	MODERATE-HIGH	LOW
HIDD-3	LOW	LOW
HIDD-4	HIGH	LOW
HIDD-5	HIGH	LOW
HIDD-6	HIGH	LOW
BARR-1	HIGH	LOW
BARR-2	LOW-MODERATE	LOW-MODERATE
BARR-3	LOW	LOW
BARR-4	LOW	LOW
BARR-5	HIGH	LOW
LARCH-1	LOW-MODERATE	LOW
LARCH-2	HIGH	LOW
LARCH-3	MODERATE-HIGH	LOW
WAP-1	MODERATE	LOW
EAGLE-1	LOW	HIGH
EAGLE-2	LOW	MODERATE-HIGH
EAGLE-3	LOW	LOW

Table 19

Recommended Treatments for Moderate to High
Root Disease Hazard Cutblocks

Disease	Age of Stand	Recommended Treatment
<hr/>		
<u>A. obscura</u>	0	If possible allow natural regeneration of site, if not plant with species other Douglas-fir.
	1+	SR lands: monitor disease losses every five years. NSR lands: monitor disease losses biennially, when losses fall below 1% (biennial mortality) for 6 years attempt to rehabilitate the site.

In all cases, the stand should be resurveyed before any intensive management procedures (such as spacing) are carried out.

<u>P. weirii</u>	0	Regenerate with a species other than Douglas-fir, Lodgepole pine is recommended.
	1+	Do nothing at present. Indicate hazard on stand records and stipulate that root disease surveys should be performed prior to any intensive management procedures (such as precommercial spacing) being carried out.

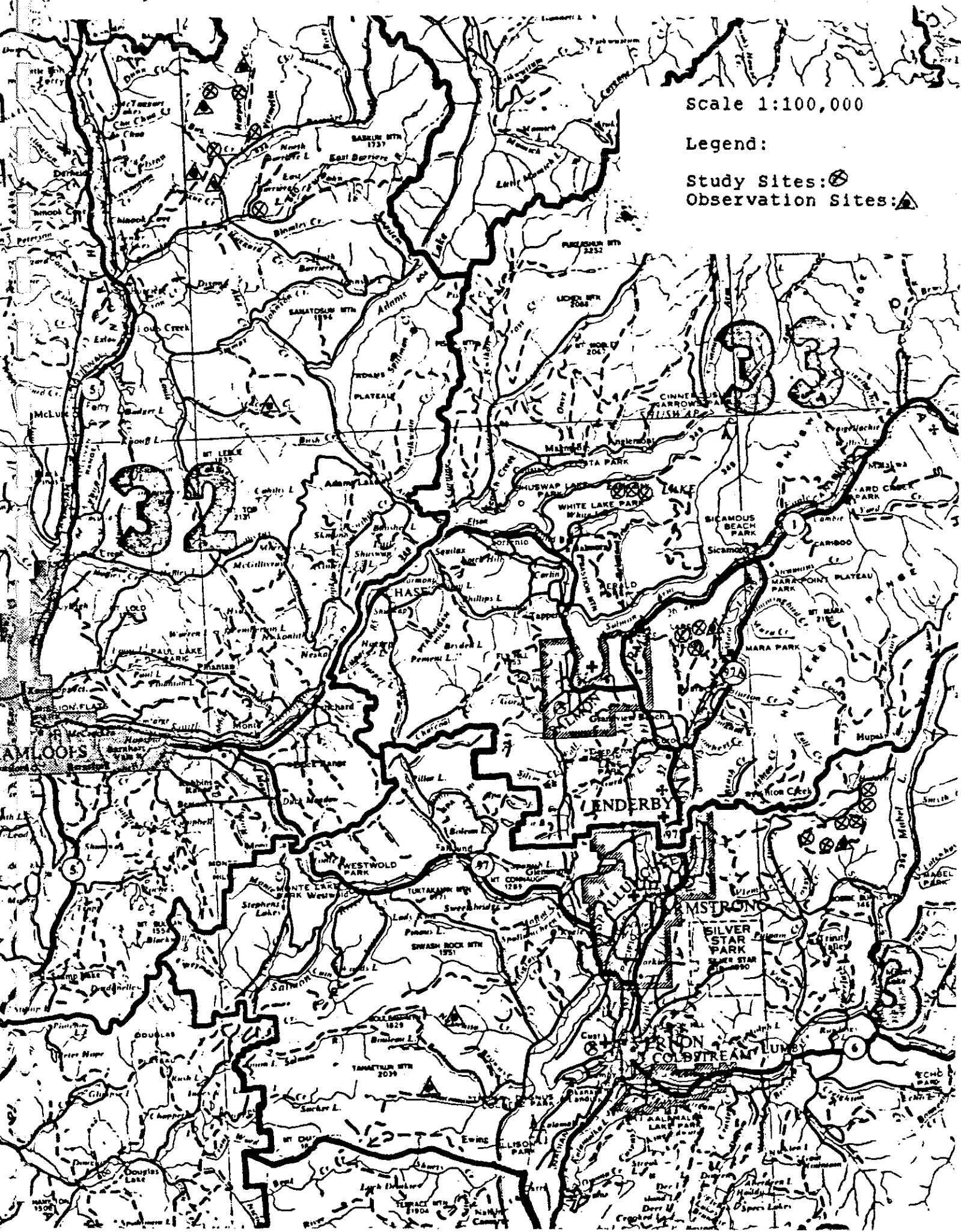
12.0 Literature Cited

- Etheridge, D.E. and R.S. Hunt. 1978. True heartrots of British Columbia. Envir. Can. For. Serv. For. Pest Leaflet 55.
- Merler, H. 1987. Personal communication.
- Morrison, D.J. 1981. Armillaria Root Disease. A guide to disease diagnosis, development and management in British Columbia. CFS. Pac. For. Res. Cen. BC-X-203.
- van der Kamp, B.J. 1987. Personal communication.
- Wallis, G.W. 1976. Phellinus (Poria) weirii Root Rot. Detection and Management Proposals in Douglas-fir stands. Envir. Can. For. Serv. Tech. Rep. 12.

APPENDICES

Appendix A
Site Descriptions

Figure 1. Location of Study Sites and observation Sites.



SITE: HIDD-1

FIGURE: 3

LOCATION: Lewis Rd.

West of Hidden Lake

FIGURE: 2

BLOCK: FC 111-M, logged 1978, planted 1980.

PLANTED SPECIES: Fd.

NATURALS: Cw, Hw, Lw, Fw.

ADJACENT STAND: CHBif, 735-P, logged 1971-72.

ECOLOGICAL ASSOCIATION: ICHm1-1MC.

CONIFERS PRESENT: Cw, Hw.

(main canopy)

PATHOLOGY IN BLOCK:

A. obscura incidence: Fd: 33/586; Lw: 1/2; Cw: 2/12

(diseased/total) Fw: 2/14; Hw: 2/60.

Hardwoods infected: Falsebox

PATHOLOGY IN ADJACENT STAND:

A. obscura was found on Cedar and Hemlock at a very high incidence level.

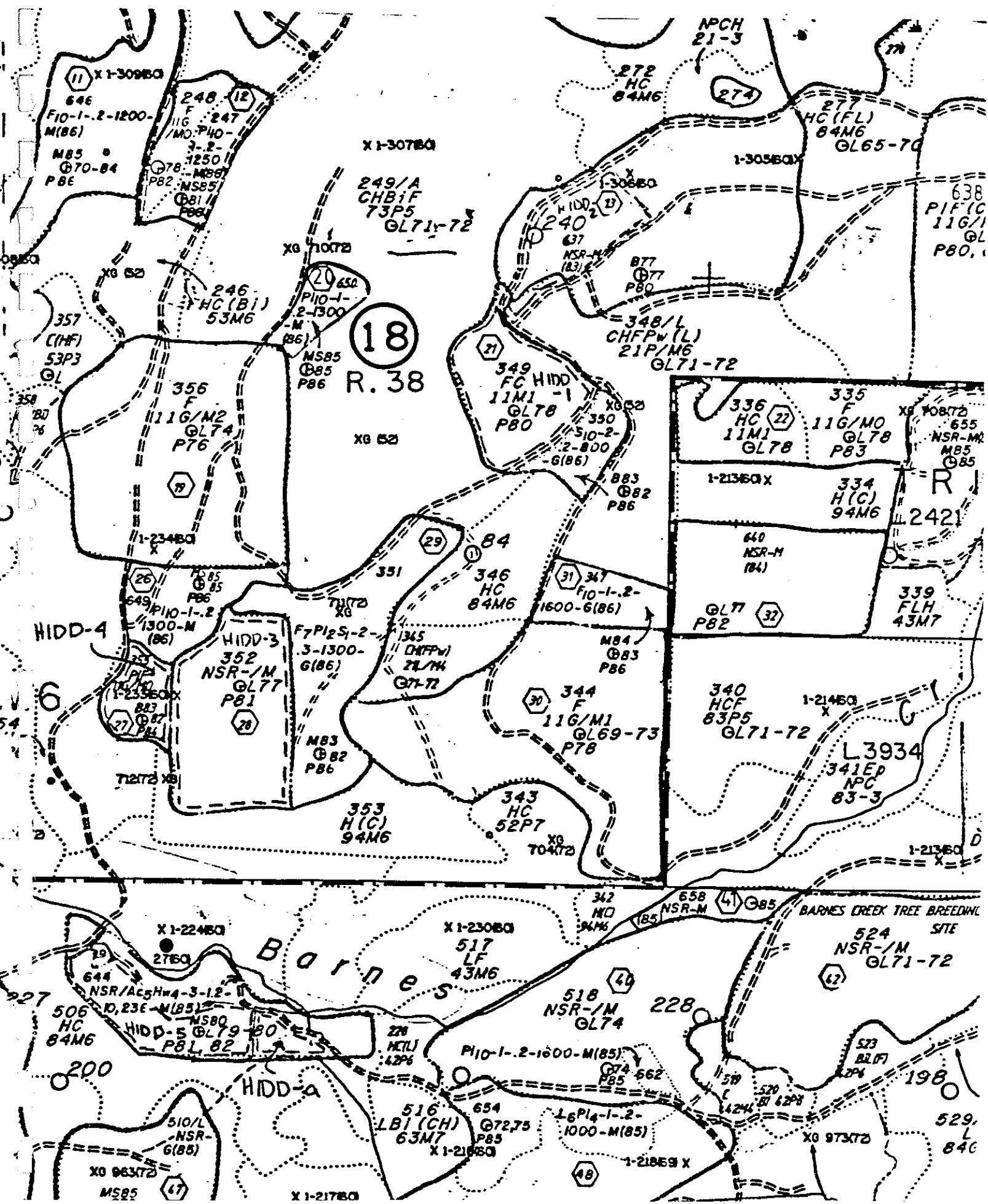
ECOLOGICAL DATA

	BLOCK	ADJACENT STAND
Soil class:	Eluviated Eutric	Eluviated Eutric
	Brunisol	Brunisol
Drainage:	Moderate	Moderate
Humus form:	Negligible	Hemimor
Effective		
rooting depth:	15 cm	>20 cm
Soil Moisture		
Regime:	Mesic	Mesic
Soil Nutrient		
Regime:	Medium-rich	Medium-rich
Texture of B		
horizon:	SiL	SiL
pH of B horiz.:	7.0	7.0

COMMENTS:

This stand was assessed as being of high risk to A. obscura due to the high biennial mortality rate (5.6%). This site should be resurveyed for root disease during a pre-stand tending silviculture survey.

Scale 1:20,000



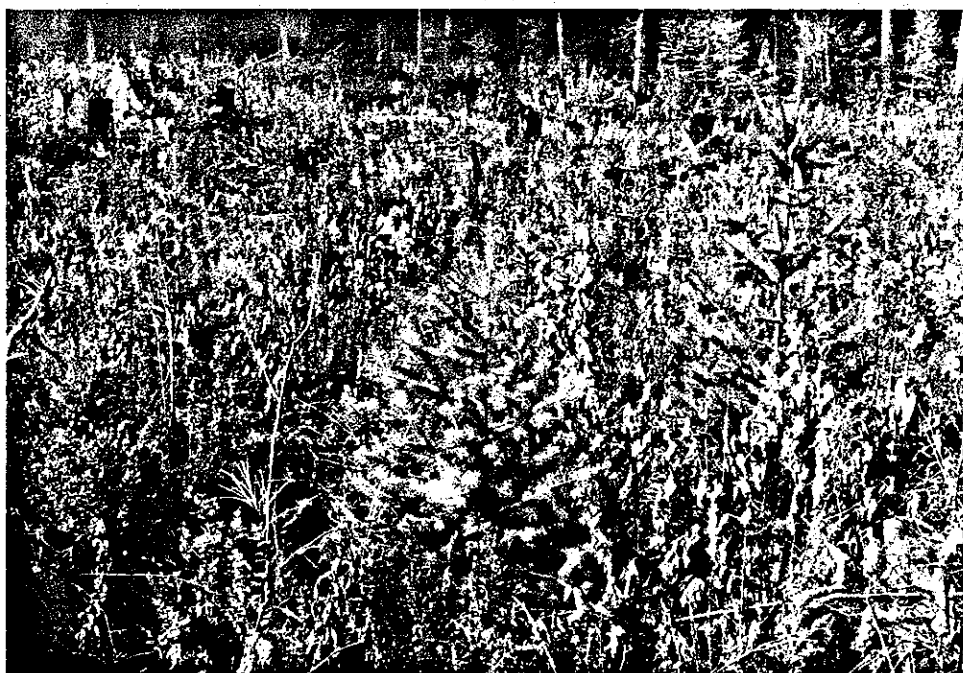


Figure 3.
HIDD-1 cutblock (above) and adjacent stand (below).



SITE: HIDD-2

FIGURE: 4

LOCATION: Lewis Rd.

West of Hidden Lake.

FIGURE: 2

BLOCK: NSR-M (83), logged 1977, burned 1977, planted 1980.

PLANTED SPECIES: Fd.

NATURALS: LW, Pw, Pl, Cw, Hw, Py, Sx.

ADJACENT STAND: CHBiF, 735-P, logged 1971-72.

ECOLOGICAL ASSOCIATION: ICHm1-1MC.

CONIFERS PRESENT: Cw, Hw.

(main canopy)

PATHOLOGY IN BLOCK:

A. obscura incidence: Fd: 9/410; Hw: 3/80.

(infected/total)

Hardwoods infected: Falsebox, Paper birch.

PATHOLOGY IN ADJACENT STAND:

A. obscura found infecting Cedar and Hemlock at a high level.

ECOLOGICAL DATA

	BLOCK	ADJACENT STAND
Soil class:	Eluviated Eutric Brunisol	Eluviated Eutric Brunisol
Drainage:	Moderate	Moderate
Humus form:	Negligible	Hemimor
Effective rooting depth:	15 cm	>20 cm
Soil Moisture Regime:	Mesic	Mesic
Soil Nutrient Regime:	Medium-rich	Medium-rich
Texture of B horizon:	SiL	SiL
pH of B horiz.:	7.0	7.0

COMMENTS:

Two year mortality due to A. obscura was 2.2%, hence this block was considered to be of moderate to high root disease hazard. This stand should be resurveyed for root disease periodically. When the mortality rate drops and remains low for a number of years silvicultural treatments may be considered.

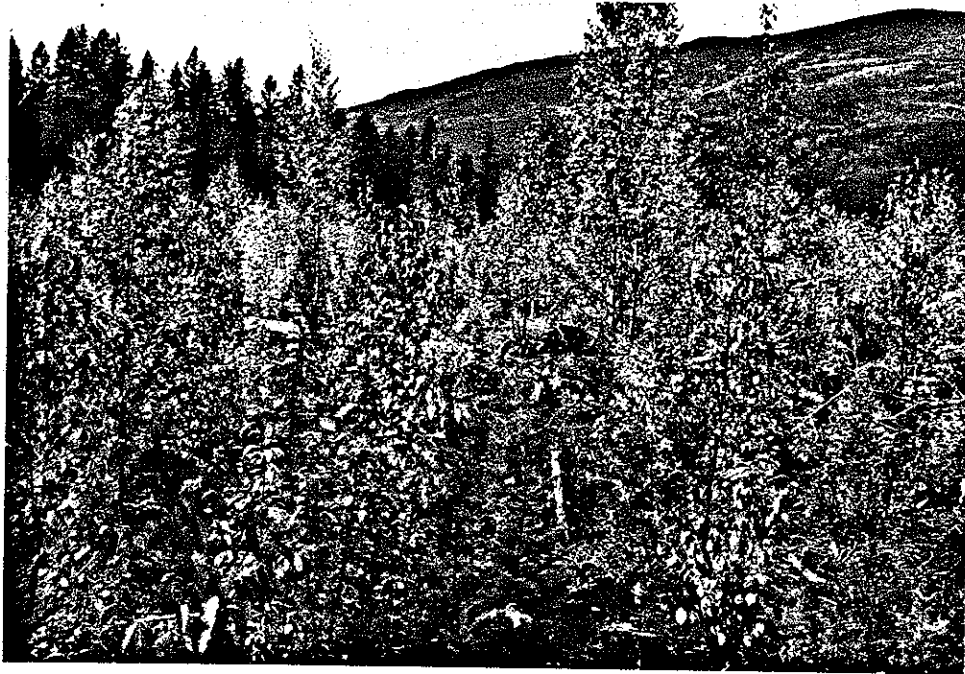


Figure 4.
HIDD-2: cutblock (above) and adjacent stand (below).



SITE: HIDD-3
FIGURE: 5 and 6

LOCATION: Toledo Jn. Main
West of Hidden Lake.
FIGURE: 2

BLOCK: NSR-M, logged 1977, planted 1981.

PLANTED SPECIES: Fd, Lw.
NATURALS: Cw, Hw, Pw, Pl.

ADJACENT STAND: CH 83P-6 and H(C) 94M-6
ECOLOGICAL ASSOCIATION: ICHm1-1MC.
CONIFERS PRESENT: Hw, Cw, Fd.
(main canopy)

PATHOLOGY IN BLOCK:

No evidence of infection by A. obscura was present in the cutblock.

PATHOLOGY IN ADJACENT STAND:

A moderate infection level of A. obscura was found on Cedar.

ECOLOGICAL DATA

	BLOCK	ADJACENT STAND
Soil class:	Eluviated Dystric Brunisol	Eluviated Dystic Brunisol
Drainage:	Well	Well
Humus form:	negligible	Hemimor
Effective rooting depth:	15 cm	15 cm
Soil Moisture Regime:	Mesic - submesic	Mesic - submesic
Soil Nutrient Regime:	Rich - very rich	Medium - (rich)
Texture of B horizon:	Si	SiL
pH of B horiz.:	7.5	6.0

COMMENTS:

This site was healthy, the rating of NSR-M was due to a brush problem which has been ameliorated.



Figure 5. (above) HIDD-3 cutblock.



Figure 6.
HIDD-3 and 4 adjacent stand.

SITE: HIDD-4
FIGURE: 6 and 7

LOCATION: Toledo Jn. Main
West of Hidden Lake.
FIGURE: 2

BLOCK: PlF 110-G/M, logged 1982, burned 1983, planted 1984

PLANTED SPECIES: Fd, Pl.
NATURALS: Lw, Pw, Hw, CW

ADJACENT STAND: CH 83P-6
ECOLOGICAL ASSOCIATION: ICHm1-1MC
CONIFERS PRESENT: Cw, Hw, Fd.
(main canopy)

PATHOLOGY IN BLOCK:

A. obscura incidence: Fd: 2/57; Pl: 4/157
(diseased/total trees)

Many Fd looked chlorotic in the block but it would be too destructive to investigate all of them, those investigated had A. obscura infection.

PATHOLOGY IN ADJACENT STAND:

Moderate level of A. obscura on Cedar.

ECOLOGICAL DATA

	BLOCK	ADJACENT STAND
Soil class:	Eluviated Dystric Brunisol	Eluviated Dystric Brunisol
Drainage:	Well	Well
Humus form:	negligible	Hemimor
Effective rooting depth:	15 cm	15 cm
Soil Moisture Regime:	Mesic	Mesic to submesic
Soil Nutrient Regime:	Medium - rich	Medium - (rich)
Texture of B horizon:	Si	SiL
pH of B horiz.:	7.5	6.0

COMMENTS:

This site had high levels of A. obscura for such a young stand. It was given a high hazard rating since if these levels continue throughout the rotation the stand will be lost. The block should be resurveyed before implementing any stand tending to determine at what level A. obscura is present.



Figure 7.
HIDD-4 cutblock.

SITE: HIDD-5
FIGURE: 8

LOCATION: Toledo Jn. Main
West of Hidden Lake
FIGURE: 2

BLOCK: NSR-M (85), logged 1978/80, mech. scar. 1980,
planted 1981/82.

PLANTED SPECIES: Pw

NATURALS: Hw, Cw, Fd.

ADJACENT STAND: HC 86M

ECOLOGICAL ASSOCIATION: ICHm1-1MC

CONIFERS PRESENT: Hw, Cw, Lw
(main canopy)

PATHOLOGY IN BLOCK:

A. obscura incidence: Pw: 20/417; (infected/total trees)

Hardwoods infected: Falsebox

Cronartium ribicola: Pw: 8/417 (infected/total trees)

PATHOLOGY IN ADJACENT STAND:

Low to moderate A. obscura infection on Cedar and Hemlock

ECOLOGICAL DATA

	BLOCK	ADJACENT STAND
Soil class:	Eluviated Dystric Brunisol	Eluviated Dystric Brunisol
Drainage:	Moderate-imperfect	Moderate - imperfected
Humus form:	Rhizomull	Hemihumimor
Effective rooting depth:	8 cm	>20 cm
Soil Moisture Regime:	Mesic - subhygric	Mesic - subhygric
Soil Nutrient Regime:	Medium - (rich)	Poor - medium
Texture of B horizon:	Si	SiL
pH of B horiz.:	6.0	6.0

COMMENTS:

The combination of biennial mortality due to A. obscura and C. ribicola on the White pine was 7%. Of this, 5% is due to A. obscura. Thus this site was given a high root disease hazard rating. It is recommended that a root disease survey be conducted prior to stand tending. Restocking this stand should not be attempted.

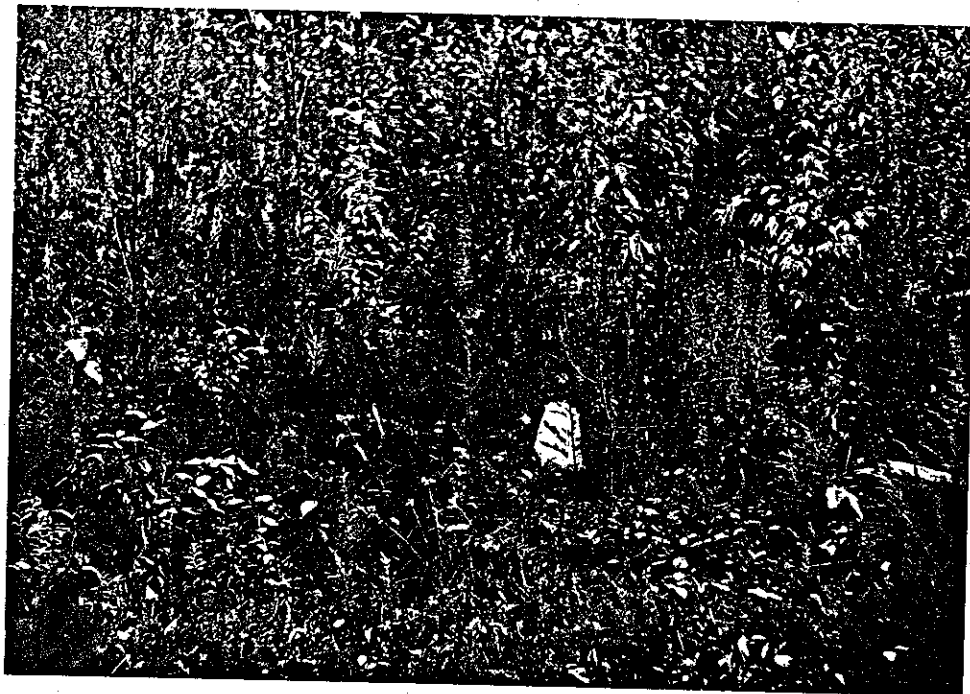


Figure 8.
HIDD-5 cutblock.

SITE: HIDD-6
FIGURE: 10

LOCATION: West of Hidden Lake
FIGURE: 9

BLOCK: F110 G/M, logged 1977, burned 1977, planted 1982.

PLANTED SPECIES: Fd
NATURALS: Pw, Lw, Hw, Cw

ADJACENT STAND: CH 73
ECOLOGICAL ASSOCIATION: ICHm1-1MC
CONIFERS PRESENT: Cw, Hw, Lw, Pw, Fd
(main canopy)

PATHOLOGY IN BLOCK:

A. obscura incidence: Pw: 9/110; Fd: 9/60
(infected/total trees)

Hardwoods infected: Falsebox, Lonicera utahensis,
Vaccinium membranaceum, Shepherdia canadensis, Betula
papyrifera

PATHOLOGY IN ADJACENT STAND:

A. obscura was found on Cedar, Hemlock and Douglas-fir in
a low to moderate incidence level.

ECOLOGICAL DATA

	BLOCK	ADJACENT STAND
Soil class:	Eluviated Dystric Brunisol	Eluviated Dystric Brunisol
Drainage:	Moderate	Moderate
Humus form:	Moder	Hemimor
Effective rooting depth:	25 cm	25 cm
Soil Moisture Regime:	Mesic	Mesic
Soil Nutrient Regime:	Medium - (rich)	Poor - medium
Texture of B horizon:	SiL	SiL-L
pH of B horiz.:	6.0	6.0

COMMENTS:

A. obscura was present in diffuse infection centers of
approximately 0.5 ha in size. Overall the site had a high
disease hazard due to the high A. obscura incidence in the
Douglas fir and White pine (15 and 8.2 percent respectively).
This stand will likely become NSR in the near future if the
infection rate remains at these levels.

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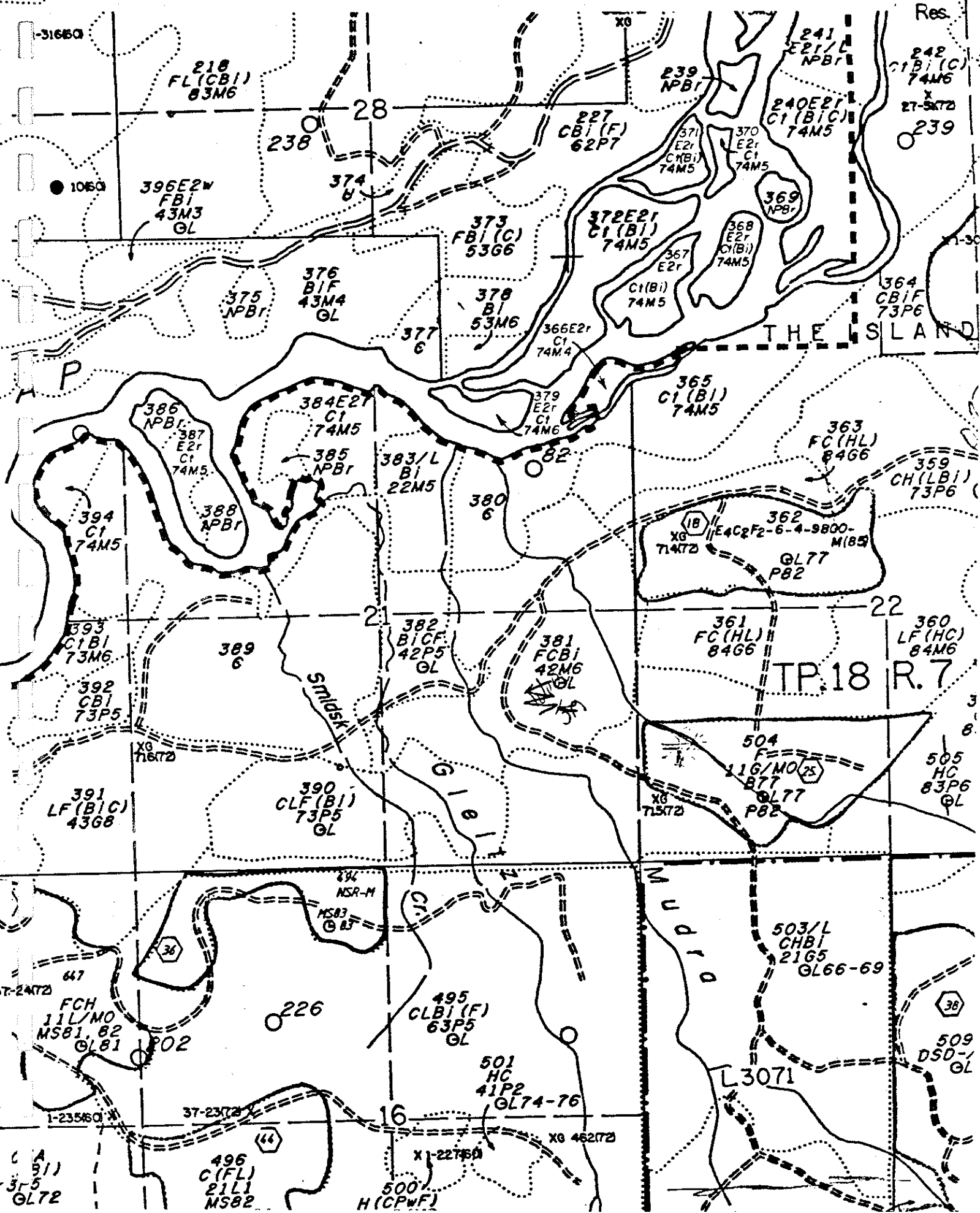




Figure 10.
HIDD-6 cutblock.

SITE: BARR-1
FIGURE: 12

LOCATION: N. Barriere Lake

FIGURE: 11

BLOCK: DSD-G (82), logged 1982.

PLANTED SPECIES: n/a
NATURALS: Sx, Pw, Fd, Cw.

ADJACENT STAND: FS-530M
ECOLOGICAL ASSOCIATION: ICHm1-5
CONIFERS PRESENT: Fd, Pw, Cw, Sx, Hw, Bl, Pl
(main canopy)

PATHOLOGY IN BLOCK:

A. obscura incidence: Pw: 14/98; Fd: 6/169; Cw: 2/55
(infected/total trees)

A. obscura was found in small infection centers.
Hardwoods infected: Falsebox, Shepherdia canadensis
P. weirii was found in residual Fd.

PATHOLOGY IN ADJACENT STAND:

A. obscura found on Sx, Cw, Pl and Hw.
P. weirii found in infection centers on Fd, evident on
windfalls. High rating for stand.

ECOLOGICAL DATA

	BLOCK	ADJACENT STAND
Soil class:	Orthic Humic Gleysol	Orthic Eutric Gleysol
Drainage:	Imperfect	Well
Humus form:	Mullmoder	Leptomoder
Effective rooting depth:	20 cm	> 25 cm
Soil Moisture Regime:	Mesic - subhygric	Submesic - mesic
Soil Nutrient Regime:	Rich - (very rich)	Medium - (rich)
Texture of B horizon:	SiCL	SL
pH of B horiz.:	7.0	7.0

COMMENTS:

Small infection centers were appearing in this DSD block.
The P. weirii on the residuals was not yet appearing on the
regeneration. This block was given a high root disease hazard
rating since the Fd and Pw had 3.5% and 14% A. obscura
infection respectively. Replanting this block is not advised
until the root disease incidence declines (if in fact it ever
does so).

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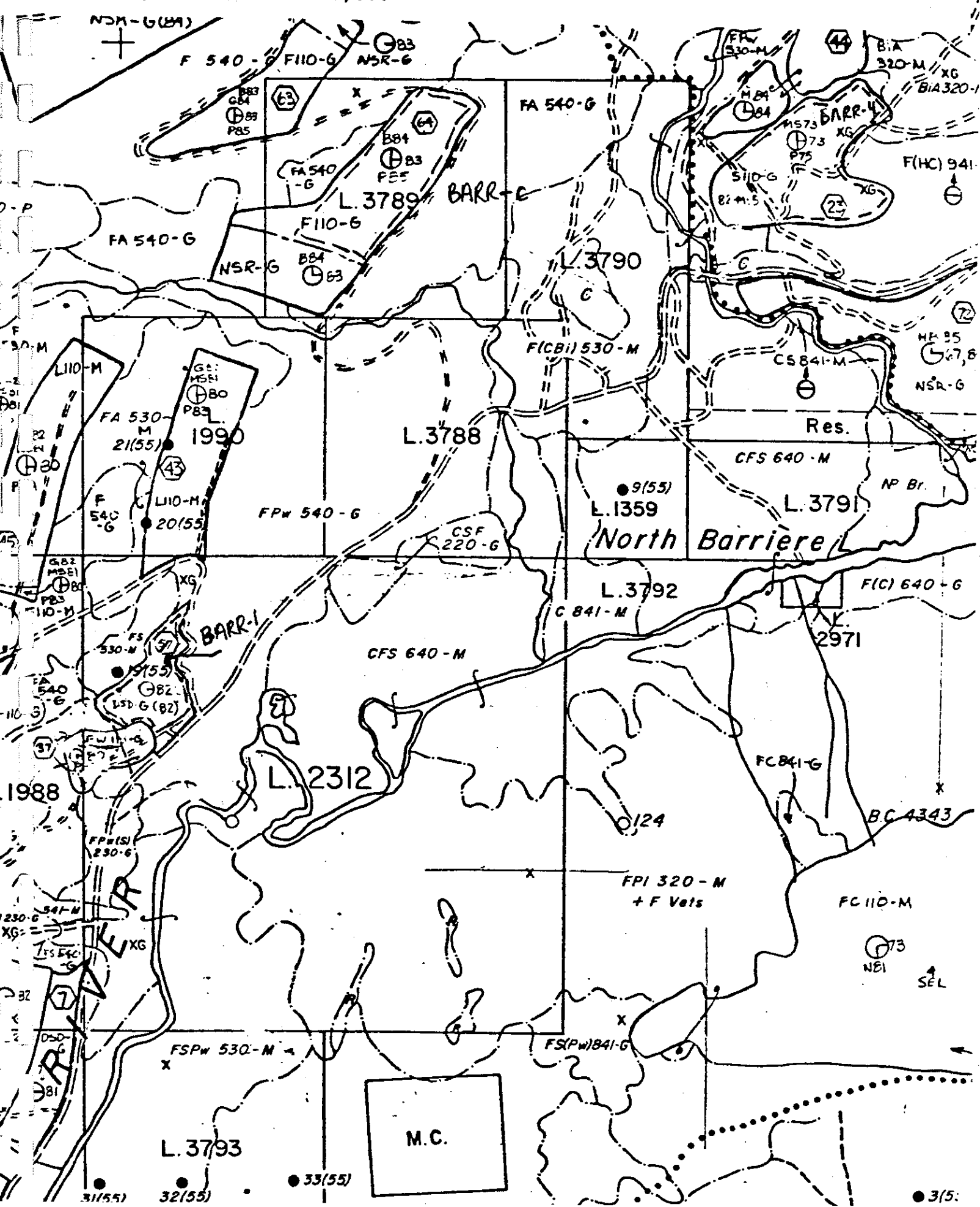




Figure 12.
BARR-1 cutblock (above) and adjacent stand (below).



SITE: BARR-2
FIGURE: 14

LOCATION: N. Barriere Lake

FIGURE: 13

BLOCK: Pw110-G, logged 1980, grassed 1982, planted 1982.

PLANTED SPECIES: Pw

NATURALS: Fd, Pl, Bl, Cw

ADJACENT STAND: F430-M

ECOLOGICAL ASSOCIATION: ICHm1-5

CONIFERS PRESENT: Cw, Fd, Pw, Sx, Ep, Hw
(main canopy)

PATHOLOGY IN BLOCK:

A. obscura incidence: Pw: 8/381; (infected/total trees)

Hardwoods infected: Falsebox

P. weirii incidence: 1 Fd; 25% of stumps

PATHOLOGY IN ADJACENT STAND:

P. weirii on Fd, Hw and Pw. High incidence in forest above the block.

ECOLOGICAL DATA

	BLOCK	ADJACENT STAND
Soil class:	Eutric Dystric	Eutric Dystric
	Brunisol	Brunisol
Drainage:	Well	Well
Humus form:	Rhizomull	Leptomull
Effective		
rooting depth:	15 cm	20 cm
Soil Moisture		
Regime:	Submesic	Mesic
Soil Nutrient		
Regime:	Medium - (rich)	Poor - medium
Texture of B		
horizon:	SL	SL
pH of B horiz.:	7.0	5.5

COMMENTS:

This area was heavily infected with P. weirii. The implications of this to the White pine are unclear. The A. obscura appears to be restricted to the lower slope. This site was assessed as low to moderate hazard for both A. obscura and P. weirii. The rating for P. weirii was low to moderate rather than high due to the fact that White pine is believed to be somewhat resistant to P. weirii.

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Figure 14.
BARR-2 cutblock (above) and adjacent stand (below).



SITE: BARR-3
FIGURE: 15

LOCATION: N. Barriere Lake
FIGURE: 13

BLOCK: F110-G, logged 1981, burned 1982, grassed 1983,
planted 1984

PLANTED SPECIES: Fd

NATURALS: Pl, Pw, Sx, Bl

ADJACENT STAND: FS 530-G

ECOLOGICAL ASSOCIATION: ICHm1-4

CONIFERS PRESENT: Fd, Pl, Pw, Cw
(main canopy)

PATHOLOGY IN BLOCK:

No root disease infection or signs of potential infection
were found in the block.

PATHOLOGY IN ADJACENT STAND:

Phellinus pini and Inonotus tomentosus were found in low
incidence on Fd.

ECOLOGICAL DATA

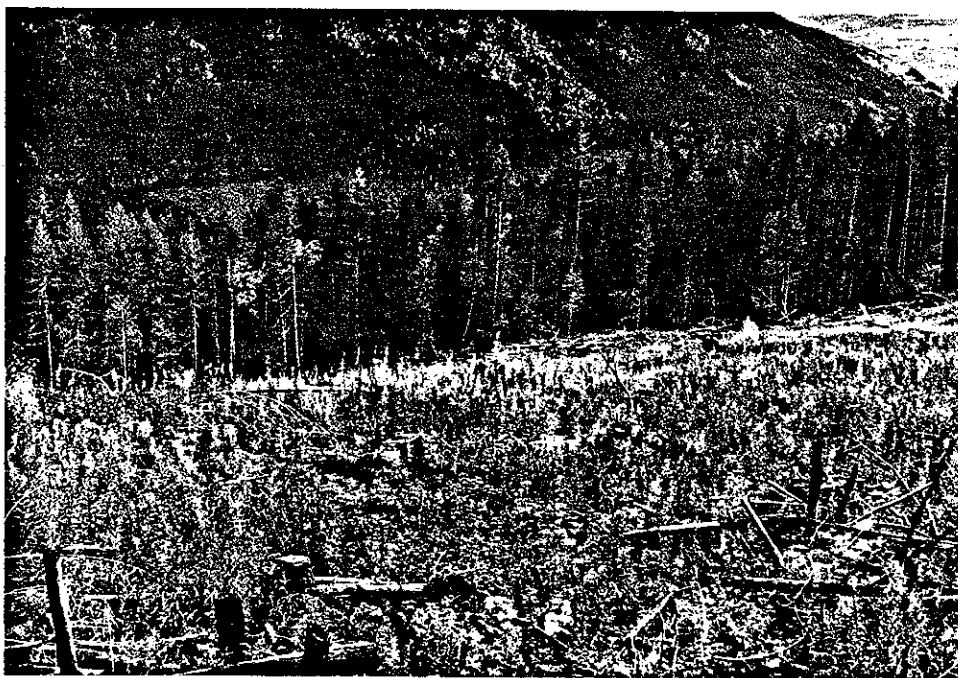
	BLOCK	ADJACENT STAND
Soil class:	Eutric Dystric Brunisol	Eutric Dystric Brunisol
Drainage:	Well	Well
Humus form:	negligible	Leptomoder
Effective rooting depth:	>30 cm	>30 cm
Soil Moisture Regime:	Submesic	Submesic
Soil Nutrient Regime:	Poor - medium	Poor - medium
Texture of B horizon:	SCL	SL
pH of B horiz.:	6.0	6.0

COMMENTS:

Although there was no apparent disease threat to this
block, the stumps on site may be infected with I. tomentosus.
However, to determine this would require extensive root
excavations. The hazard to A. obscura and P. weirii on this
site was low.



Figure 15.
BARR-3 cutblock (above) and adjacent stand (below).



SITE: BARR-4
FIGURE: 16

LOCATION: N. Barriere Lake

FIGURE: 11

BLOCK: S110-G, logged 1973, mech. scar. 1973, planted 1975

PLANTED SPECIES: Sx

NATURALS: Pl, Pw, Cw, Fd, Bl

ADJACENT STAND: FCH 831-M

ECOLOGICAL ASSOCIATION: ICHm1-5

CONIFERS PRESENT: Cw, Hw, Pw, Fd
(main canopy)

PATHOLOGY IN BLOCK:

A. obscura incidence: a few Sx and Pl near the road and by the old growth were infected
Hardwoods infected: Falsebox

PATHOLOGY IN ADJACENT STAND:

The adjacent stand had Phellinus pini on Pw, P. weirii and Heterobasidion annosa on Hw and A. obscura on Cw and Hw. This stand is extensively infected.

ECOLOGICAL DATA

	BLOCK	ADJACENT STAND
Soil class:	Orthic humo-ferric Podzol	Ortho humo-ferric Podzol
Drainage:	Well	Moderate
Humus form:	negligible	Mormoder
Effective rooting depth:	15 cm	>25 cm
Soil Moisture Regime:	Mesic	Mesic
Soil Nutrient Regime:	Poor - medium	Medium - (rich)
Texture of B horizon:	LS	SiL
pH of B horiz.:	6.0	7.0

COMMENTS:

This stand appeared to be at low risk to A. obscura since the disease had not yet manifested itself in the block. The presence of P. weirii infected stumps on the block indicates moderate hazard to this disease.



Figure 16. BARR-4
cutblock (above) and
adjacent stand (right).



SITE: BARR-5
FIGURE: 18

LOCATION: N. Barriere Lake
FIGURE: 17

BLOCK: F110-G + F vets

PLANTED SPECIES: n/a
NATURALS: Fd, Pl

ADJACENT STAND: n/a
ECOLOGICAL ASSOCIATION: IDFj1-3
CONIFERS PRESENT: n/a
(main canopy)

PATHOLOGY IN BLOCK:

Approximately 60% of this area was infected with A. obscura, there were several infection centers.

Hardwoods infected: Falsebox, Ceanothus sanguineus,
Shepherdia canadensis, Amelanchier alnifolia, Rosa gymnocarpa.

PATHOLOGY IN ADJACENT STAND:

n/a

ECOLOGICAL DATA

	BLOCK	ADJACENT STAND
Soil class:	Orthic Dystric Brunisol	n/a
Drainage:	Well	
Humus form:	Leptomoder	
Effective rooting depth:	20 cm	
Soil Moisture Regime:	Submesic	
Soil Nutrient Regime:	Poor - medium	
Texture of B horizon:	SiL	
pH of B horiz.:	6.0	

COMMENTS:

This site was very heavily infected with A. obscura for such a young stand (60% at 35 years). As such this stand was given a high root disease hazard rating. It is recommended that this stand be salvage cut for firewood or fence posts and put into fallow for several years before any attempt and rehabilitation is attempted. Alternatively, the site could be converted to pasture as there are several ranches in the vicinity. Stumping of the site is another alternative providing care is taken not to damage the site (through soil compaction).

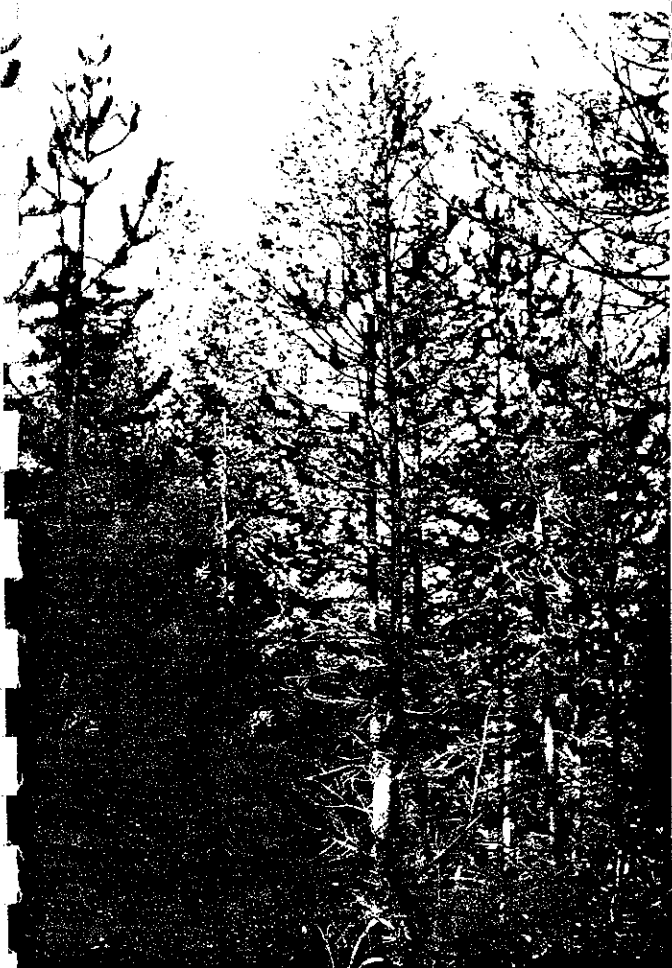
Figure 17. Location of Barriere Site 5 at Observation Site a.

Scale 1:20,000

Figure 17. Location of Barriere Site 5 at Observation Site a.

Scale 1:20,000

Figure 18.
BARR-5 below and right.



SITE: LARCH-1
FIGURE: 20

LOCATION: Larch Hills
FIGURE: 19

BLOCK: NSR-M, logged 1977, planted 1981

PLANTED SPECIES: Lw, Fd
NATURALS: Pw, Cw, Sx, Hw, Bl

ADJACENT STAND: CHF 841-M
ECOLOGICAL ASSOCIATION: ICHm1-5
CONIFERS PRESENT: Cw, Lw, Pw, Hw, Sx, Ep, Fd
(main canopy)

PATHOLOGY IN BLOCK:

Although transects across the site revealed no A. obscura infection, one area on a ridge had a moderate level of A. obscura. Many stumps had Armillaria on them but it was not attacking the young conifers.

Hardwoods infected: Falsebox (on ridge)

PATHOLOGY IN ADJACENT STAND:

A high incidence of A. obscura was found in the Fd and Cw.

ECOLOGICAL DATA

	BLOCK	ADJACENT STAND
Soil class:	Eluviated Eutric Brunisol	Eluviated Eutric Brunisol
Drainage:	Moderate	Moderate
Humus form:	negligible	Leptomoder
Effective rooting depth:	15 cm	> 25 cm
Soil Moisture Regime:	Mesic	Mesic
Soil Nutrient Regime:	Rich	Medium - (rich)
Texture of B horizon:	SiCL	L
pH of B horiz.:	7.5	7.0

COMMENTS:

This block was heavily disturbed. A. obscura was detected in the regen only on one undisturbed ridge. On the basis of the low root disease incidence in the conifer regen the site was rated as low to moderate hazard to Armillaria. In fact, since the adjacent stand and stumps on the cutblock showed high A. obscura incidence, the incidence level of this disease may increase in the near future. The block should therefore be resurveyed in two to three years to reassess hazard. Efforts to restock the site should be delayed until disease levels decrease. When restocking the block Douglas fir and White pine should be avoided.

Figure 19. Location of Larch Hills Sites.

Scale 1:20,000

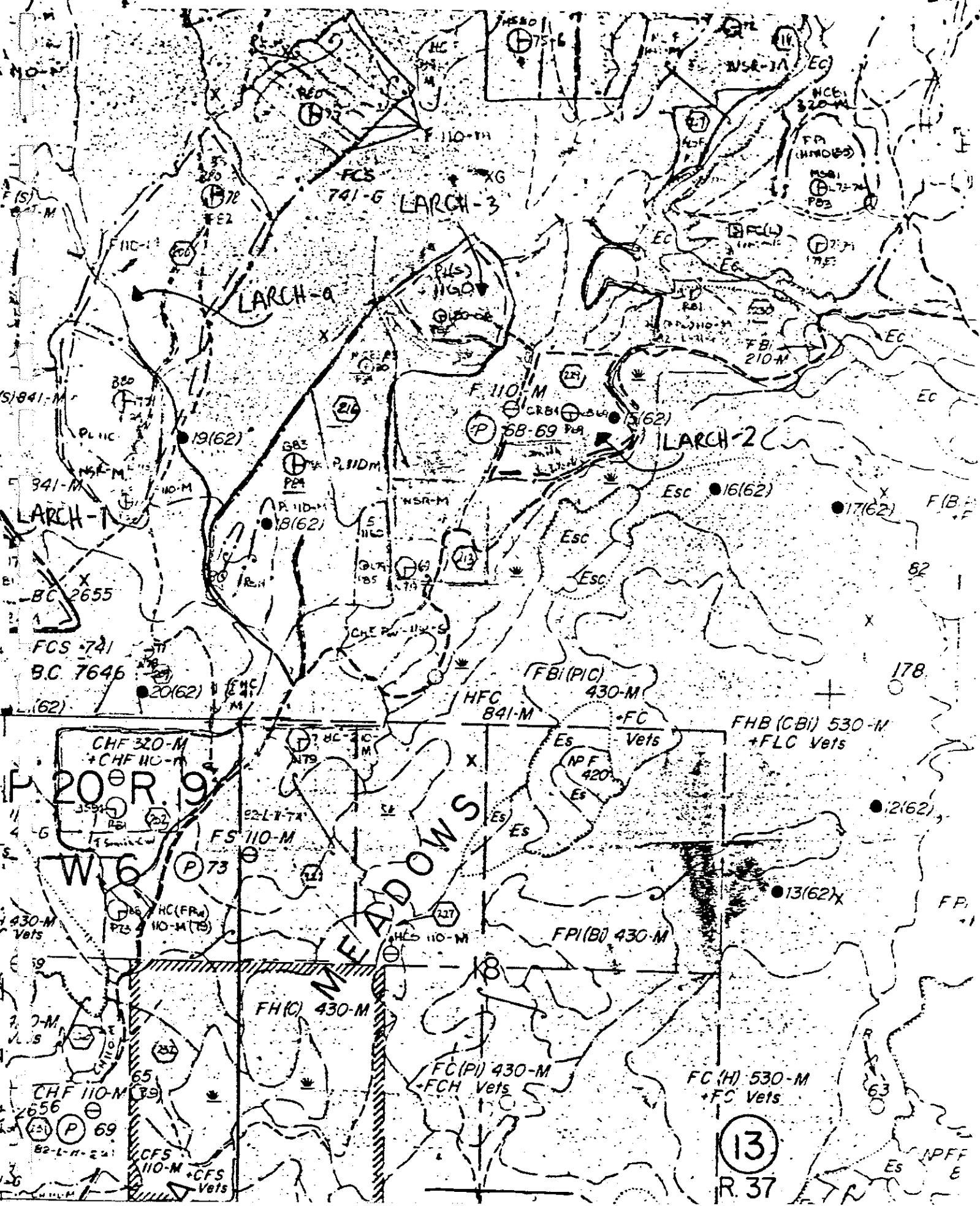




Figure 20.
LARCH-1 cutblock
(above) and adjacent
stand (left).

SITE: LARCH-2
FIGURE: 21

LOCATION: Larch hills

FIGURE: 19

BLOCK: F110-M, Pl 1969, Logged 1968-9, CR 1984

PLANTED SPECIES: Fd, Sx
NATURALS: Pl, Hw, Pw, Cw

ADJACENT STAND: FCS 741-G
ECOLOGICAL ASSOCIATION: ICHm-5
CONIFERS PRESENT: Hw, Cw, Fd, Ep, Pw
(main canopy)

PATHOLOGY IN BLOCK:

A. obscura incidence Fd 63/427, Cw 8/73, Sx 12/41
Hardwoods infected: Falsebox a good indicator

PATHOLOGY IN ADJACENT STAND:

Cedar infected with A. obscura at moderate levels

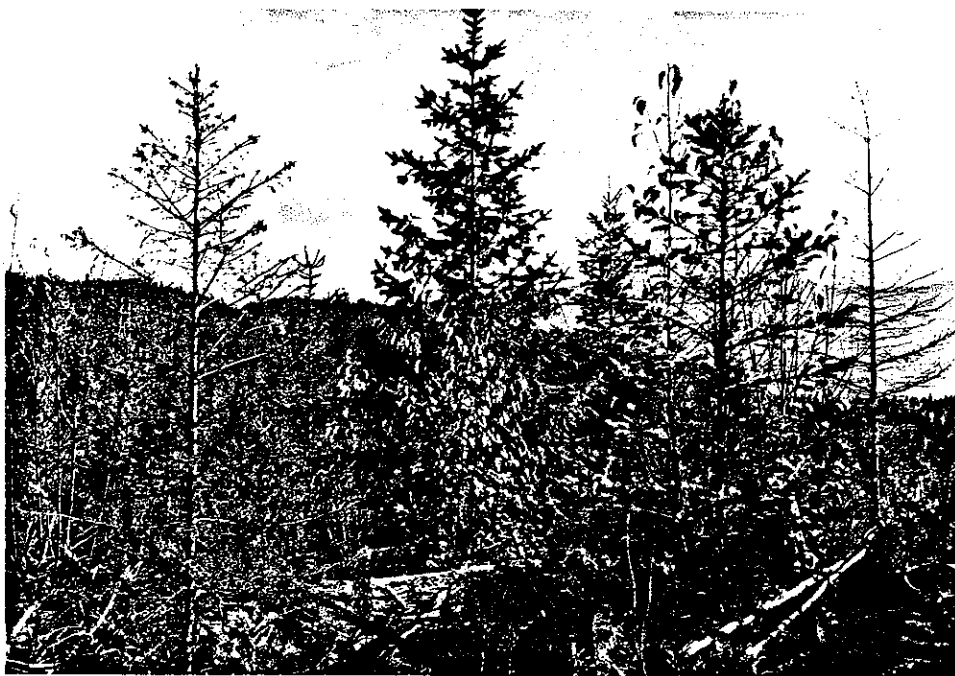
ECOLOGICAL DATA

	BLOCK	ADJACENT STAND
Soil class:	Eluviated Eutric Brunisol	
Drainage:	Imperf.-very well	Well
Humus form:	Negligible	Mormoder
Effective rooting depth:	15-30 cm.	>30 cm.
Soil Moisture	Subxeric, submesic	
Regime:	to subhygric	Mesic
Soil Nutrient	Poor-medium,	
Regime:	medium, medium-rich	Medium- rich
Texture of B horizon:	SiCL, L, Sl	SiL
pH of B horiz.:	6.0, 7.0	7.0

COMMENTS:

Parts of this block had been thinned in 1984. Both thinned and unthinned areas had A. obscura incidence. This block was rated as high hazard due to the high level of infection. It is strongly recommended that no rehabilitation or additional intensive management efforts be expended on this site. The site would make a convincing demonstration area of the potential effects of root disease and of the inadvisability of spacing such sites.

Figure 21. LARCH-2
cutblock (above and right).



SITE: Larch-3
FIGURE: 22 and 23

LOCATION: Larch Hills
FIGURE: 19

BLOCK: P1110-G, Logged 1980-82, Planted 1984

PLANTED SPECIES: P1
NATURALS:

ADJACENT STAND: FCS 741-G
ECOLOGICAL ASSOCIATION: ICHm1-5
CONIFERS PRESENT: Hw,Cw,Fd,Ep,Pw
(main canopy)

PATHOLOGY IN BLOCK:

A. obscura incidence: 2% in P1
Hardwoods infected: No hardwoods established on site

PATHOLOGY IN ADJACENT STAND:

Cedar moderately infected with A. obscura.

ECOLOGICAL DATA

	BLOCK	ADJACENT STAND
Soil class:	Eluviated Eutric Brunisol	
Drainage:	Well	Well
Humus form:	Negligible	Mormoder
Effective rooting depth:	15 cm.	>20 cm.
Soil Moisture Regime:	Subxeric	Mesic
Soil Nutrient Regime:	Medium	Medium - (rich)
Texture of B horizon:	SL	SiL
pH of B horiz.:	7.0	7.0

COMMENTS:

Two percent of the Lodgepole pine in this two year old plantation were infected by A. obscura. This block was given a moderate to high hazard rating due to the stands young age. The level of mortality (just under 1% per year) was high for such a young plantation. It is recommended that this site be resurveyed periodically (every 3 to 4 years) and that the infection status and hazard rating be considered before any stand tending procedures are carried out.

Figure 22. (right)
LARCH-3 cutblock.



Figure 23. (left).
Adjacent stand
LARCH-2 and 3.

SITE: WAP-1
FIGURE: 25

LOCATION: Wap Creek south
Three Valley Gap.
FIGURE: 24

BLOCK: F(S)110-G, Logged 1962-1968, Planted 1971

PLANTED SPECIES: Fd
NATURALS: Hw,Cw,Pw

ADJACENT STAND: H(C)831-P
ECOLOGICAL ASSOCIATION: ICHw-1
CONIFERS PRESENT: Hw,Cw,Pw
(main canopy)

PATHOLOGY IN BLOCK:

A. obscura incidence: 4% of Douglas-fir on site
Hardwoods infected: Falsebox and Salix sp.

PATHOLOGY IN ADJACENT STAND:
N/A

ECOLOGICAL DATA

	BLOCK	ADJACENT STAND
Soil class:	Orthochemoferric Podzol	
Drainage:	Very well	Very well
Humus form:	Negligible	Hemimor
Effective rooting depth:	20 cm.	>25 cm.
Soil Moisture Regime:	Mesic	Mesic
Soil Nutrient Regime:	Poor-(medium)	Poor-(medium)
Texture of B horizon:	L	SL
pH of B horiz.:	4.5	4.5

COMMENTS:

A. obscura was present in small disease centers. The hazard in this block was moderate due to the advanced age of the plantation. Had the plantation been less than five years old the hazard would have been rated as high. It is recommended that this stand be surveyed for root diseases prior to carrying out any stand tending procedures.

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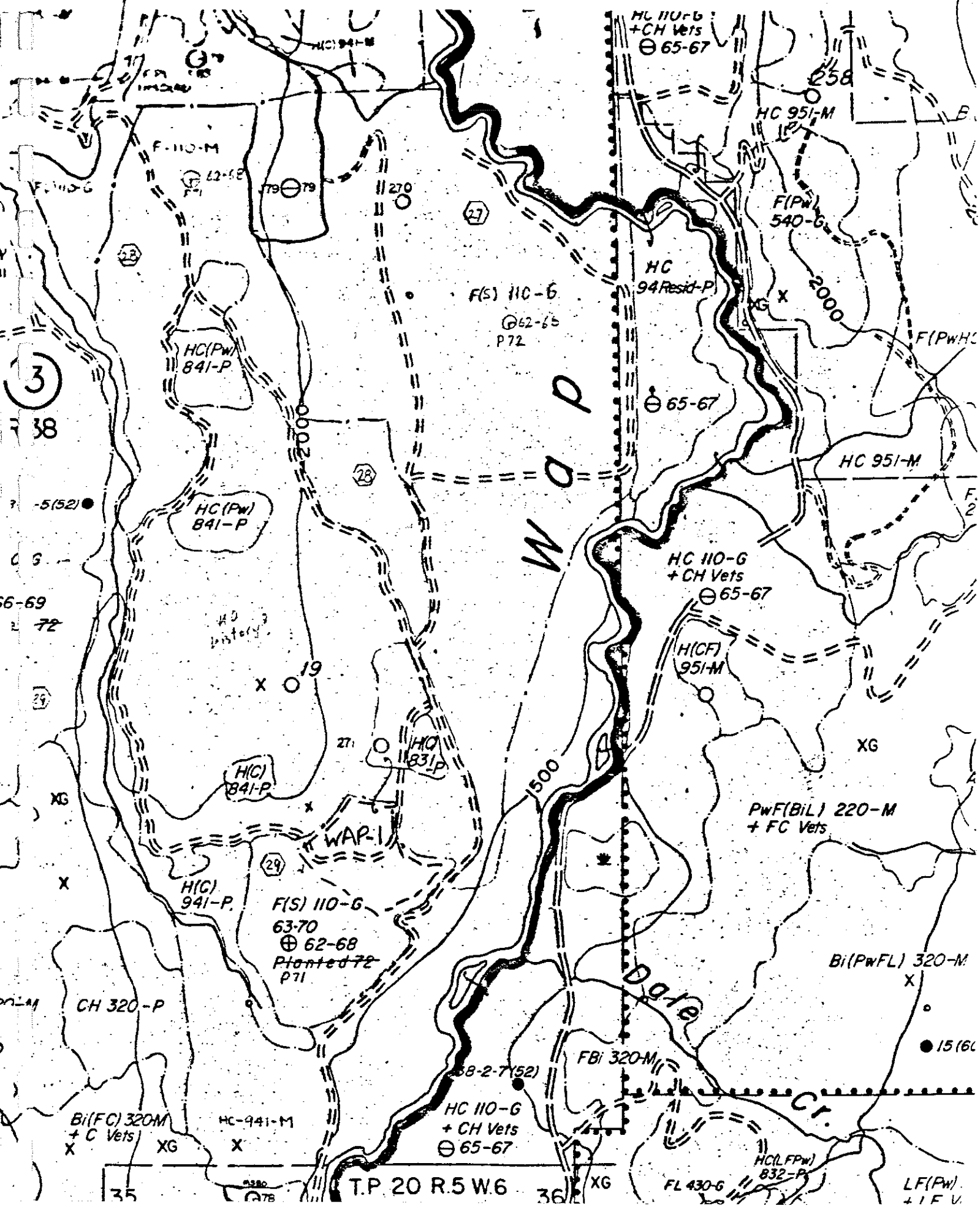




Figure 25.
WAP-1 cutblock.

SITE: EAGLE-1
FIGURE: 27

LOCATION: South of Eagle Bay

FIGURE: 26

BLOCK: P1110-M, Logged 1979-80, Mechanically Scarified
1982-1984, Grass seeded 1983, Planted 1985

PLANTED SPECIES: P1
NATURALS:

ADJACENT STAND: FCHBi(A)630-M, Logged 1950
ECOLOGICAL ASSOCIATION: ICHm1-5
CONIFERS PRESENT: Fd,Pl,Cw,Hw
(main canopy)

PATHOLOGY IN BLOCK:

No root disease present in regen in block.

P. weirii was present in many of the stumps within the block.

PATHOLOGY IN ADJACENT STAND:

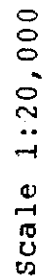
High incidence of P. weirii in Douglas-fir and Lodgepole pine.

ECOLOGICAL DATA

	BLOCK	ADJACENT STAND
Soil class:	Eluviated Eutric Brunisol	
Drainage:	Moderate	Well
Humus form:	Negligible	Mor-moder
Effective		
rooting depth:	15 cm.	20 cm.
Soil Moisture		
Regime:	Mesic	Mesic
Soil Nutrient		
Regime:	Medium-(rich)	Medium- (rich)
Texture of B		
horizon:	SiL	SiL
pH of B horiz.:	6.5	6.5

COMMENTS:

Although no root disease was present on the regeneration the site was still deemed to be at risk due to the presence of P. weirii in stumps on the site. Although the plantation may have been too young for A. obscura to be expressed in the conifer seedlings, the lack of expression on hardwoods indicates a low A. obscura hazard. The hazard rating due to P. weirii is difficult to quantify. Due to the high incidence of the disease on stumps in the block and on trees in the adjacent stand a high hazard rating was given. However, the meaning of this rating in terms of expected losses to the disease at rotation age is unclear.



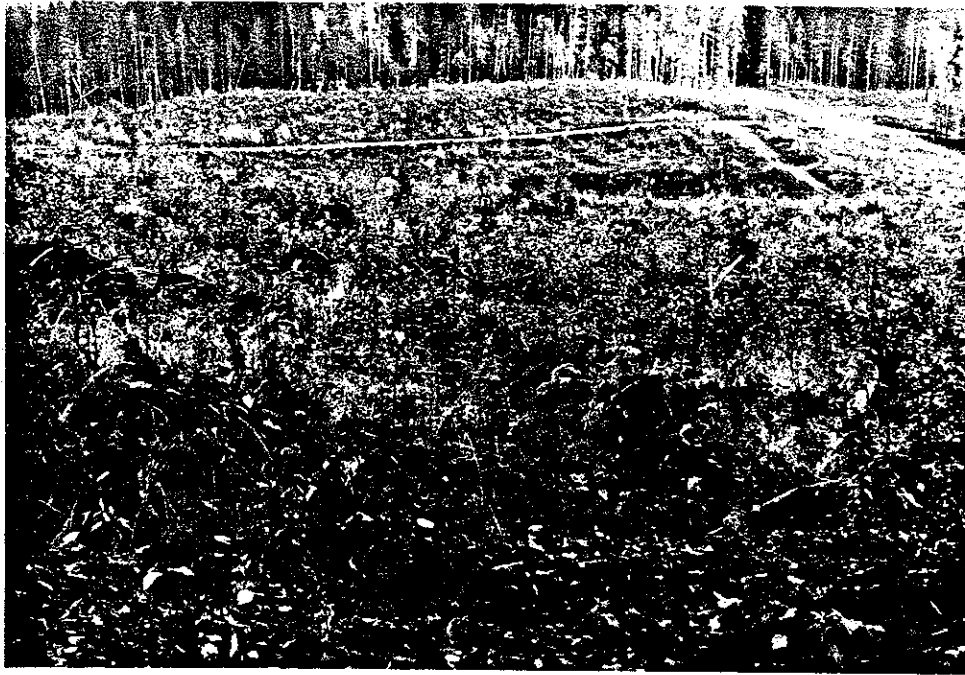


Figure 27.
EAGLE-1 cutblock (above) and adjacent stand (below).



SITE: EAGLE-2
FIGURE: 28

LOCATION: South of Eagle
Bay.
FIGURE: 26

BLOCK: NSR-M(84), MS 1980-84, Logged 1978

PLANTED SPECIES: N/A
NATURALS: N/A

ADJACENT STAND: FCHB1(A)630-M, Logged 1950
ECOLOGICAL ASSOCIATION: ICHM1-5
CONIFERS PRESENT: Fd,Pl,Cw,Hw
(main canopy)

PATHOLOGY IN BLOCK:
P. weirii present in stumps on site.

PATHOLOGY IN ADJACENT STAND:
High incidence of P. weirii in Douglas-fir and Lodgepole
pine

ECOLOGICAL DATA

	BLOCK	ADJACENT STAND
Soil class:	Eluviated Eutric Brunisol	
Drainage:	Moderate	Well
Humus form:	Negligible	mormoder
Effective rooting depth:	15 cm.	20 cm.
Soil Moisture Regime:	Mesic	Mesic
Soil Nutrient Regime:	Medium-(rich)	Medium-(rich)
Texture of B horizon:	SiL	SiL
pH of B horiz.:	6.5	6.5

COMMENTS:

This site was assessed as being at low hazard to A. obscura. It was at moderate to high hazard to P. weirii due to the presence of the disease at high levels in the adjacent stand and moderate levels in the cutblock itself. It is recommended that the site be restocked by planting P. weirii resistant species such as Lodgepole pine or White pine.



Figure 28.
EAGLE-2 cutblock (above)
and adjacent stand (right).



SITE: EAGLE-3

LOCATION: South of Eagle Bay

FIGURE: 29

FIGURE: 26

BLOCK: F110-M, Logged 1970, MB 1971, 1972, Burned 1984,
Planted 1973

PLANTED SPECIES: Fd

NATURALS: Cw, Pw, Hw, Sx

ADJACENT STAND: HC932-P

ECOLOGICAL ASSOCIATION: ICHm1-5

CONIFERS PRESENT: Fd, Hw, Cw, Sx
(main canopy)

PATHOLOGY IN BLOCK:

A. obscura incidence: Many small centers scattered
throughout the block.

PATHOLOGY IN ADJACENT STAND:

None

ECOLOGICAL DATA

	BLOCK	ADJACENT STAND
Soil class:	Eluviated Eutric Brunisol	
Drainage:	Moderate	Well
Humus form:	Negligible	Mormoder
Effective rooting depth:	15 cm.	25 cm.
Soil Moisture Regime:	Mesic	Mesic
Soil Nutrient Regime:	Medium-(rich)	Medium-(rich)
Texture of B horizon:	SiL	SiL
pH of B horiz.	6.5	6.5

COMMENTS:

Losses to A. obscura appeared to be just beginning to pick up. This was possibly due to provision of stumps for A. obscura colonization through brushing of the site. Given the low incidence of A. obscura on the site (approx. 1.5%) and the age of the plantation the hazard rating was low. Nevertheless, due to the presence of A. obscura on the block another root disease survey is recommended prior to initiation of any stand tending procedures on the site.

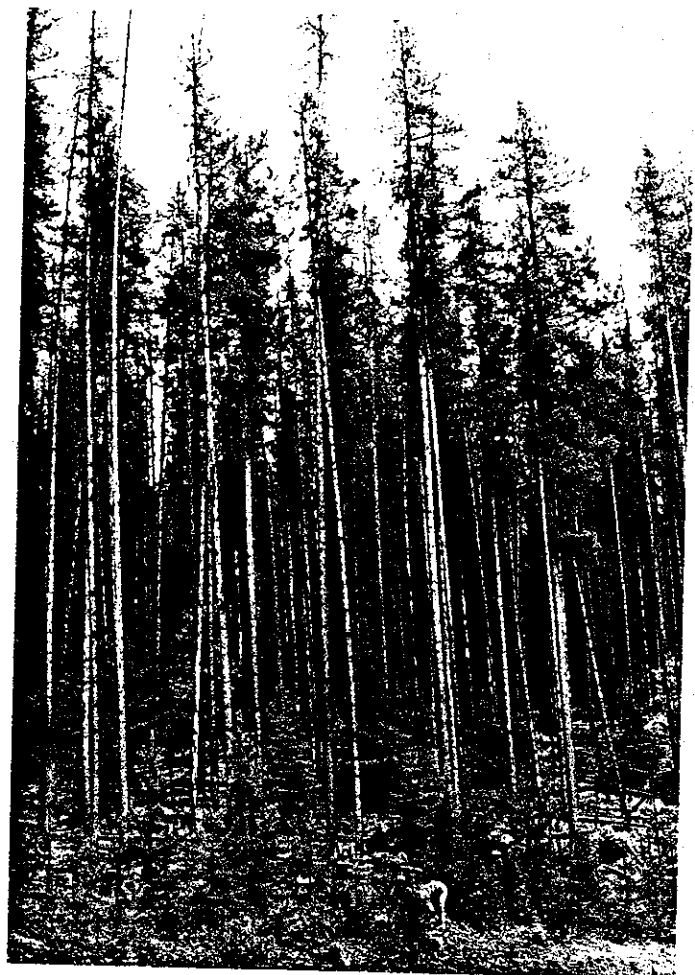


Figure 29. (right and above). EAGLE-3 cutblock.





Figure 30. (above and right) Cicero Creek observation area.



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6A

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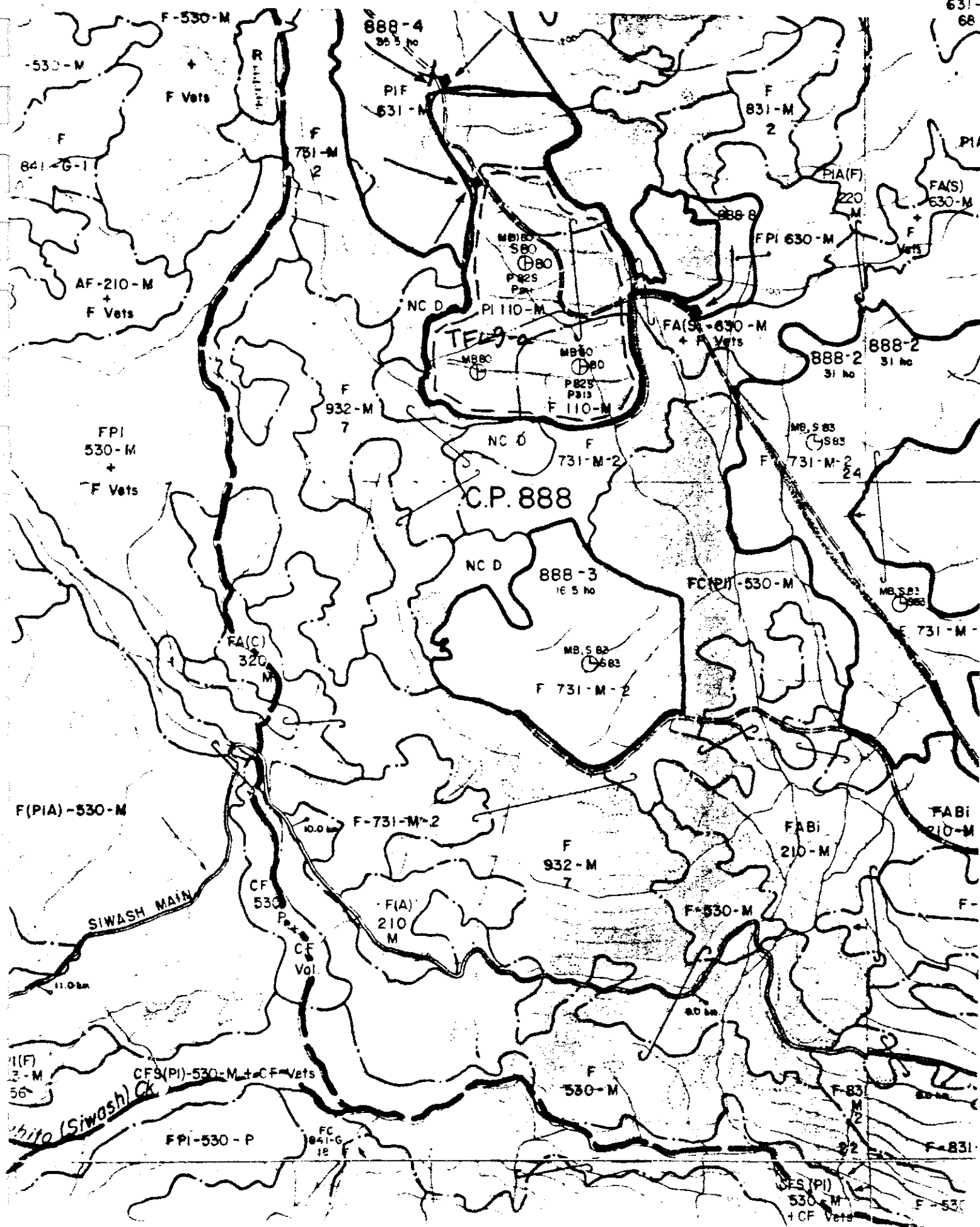
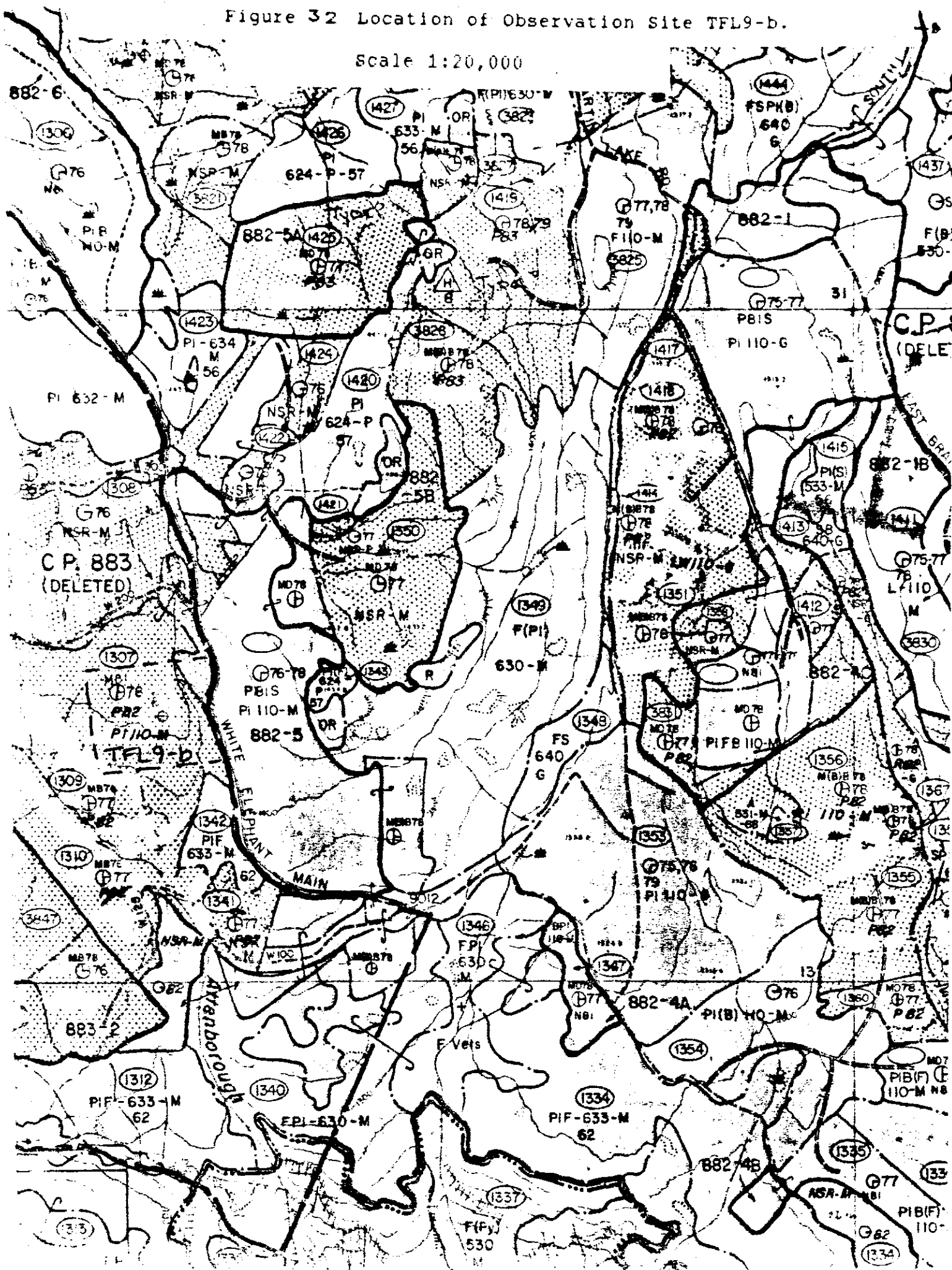


Figure 32 Location of Observation Site TFL9-b.

Scale 1:20,000



Appendix B.

**A Field Guide to Root Disease Identification
and Assessment on NSR Lands**

**FRDA Research Project 3.8
March 1987.**

PATHOCON CONSULTING

**John Schulting
Maureen Curran**

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1.0 FIELD IDENTIFICATION OF ROOT DISEASES

1.1 Armillaria obscura:

Armillaria obscura is a serious forest pest in southern British Columbia. It attacks all species of conifers and some hardwood species causing decline and death. When examining dead or declining trees suspected of having Armillaria there are several characteristics to look for:

- A. Pronounced resin flow at the base of the stem.
- B. Fan-like creamy white mycelium beneath and within the bark of the roots and lower bole (Figures 1 and 2).
- C. Armillaria mushrooms growing from rotted or mycelium impregnated roots (Figure 3).
- D. Black, stringy or root like rhizomorphs attached to the roots.
- E. Spongy pocket rot within the roots or butt.

Of these characteristics, the fan-like mycelium and basal resinosis are the most reliable indicators. Armillaria mushrooms and rhizomorphs are produced, seasonally or sporadically and are thus not always present. Hardwood symptomology is similar to that described but basal resinosis does not occur (Figures 4, 14 to 23).

1.2 Phellinus weirii:

Phellinus weirii is also a serious southern interior forest pest. Many species of conifer are attacked but hardwoods are not affected (Table 1). When examining dead or declining conifers for P. weirii the following characteristics should be looked for:

- A. White powdery mycelium on the surface of roots.
- B. Red staining in the root xylem, often extending into the butt.
- C. Laminar decay of the xylem resulting in easily separated, pitted growth rings. The pits are empty or filled with chestnut brown mycelium (Figure 5).

The external root mycelium is generally only found on roots within mineral soil. The mycelium is very thin and very fragile and is thus easily removed if the roots are excavated.

Table 1. Species susceptibility to Phellinus weirii:

Highly to moderately resistant:

Western red cedar (Thuja plicata Donn ex D. Don.)

Pine spp. (Pinus spp.)

Susceptible:

Douglas-fir (Pseudotsuga menziesii (Mirb.) Franco)

True Firs (Abies spp.)

Spruces (Picea spp.)

Western larch (Larix occidentalis Nutt.)

Western hemlock (Tsuga heterophylla (Raf.) Sarg.)

Figure 1.
Fan-like mycelium of
Armillaria obscura on
Western Hemlock
(Tsuga heterophylla).



Figure 2.
Mycelium on the
inside of the bark
at the base of an
Armillaria killed
Douglas-fir.





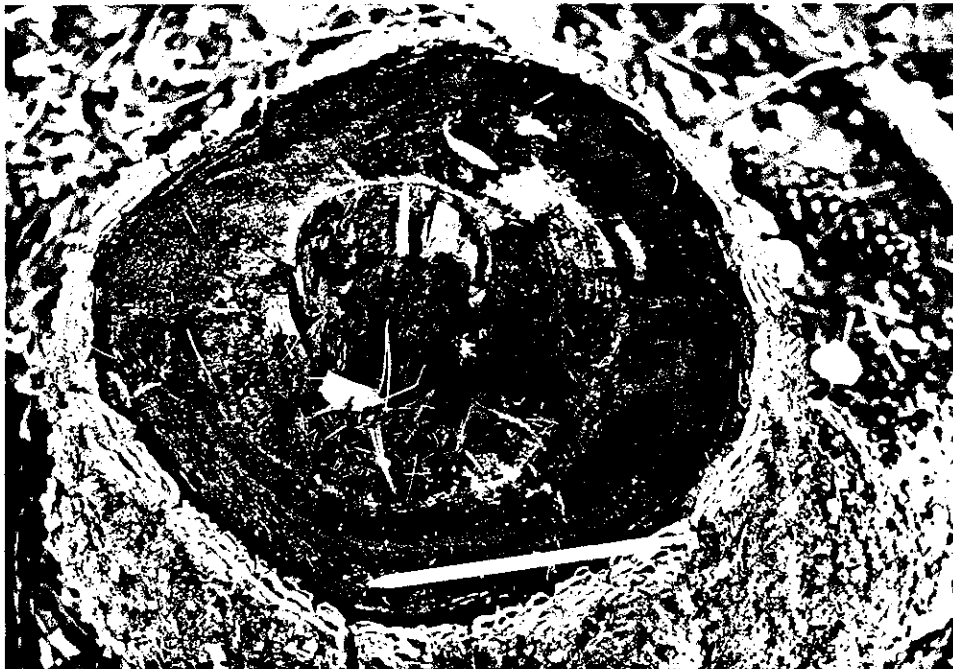
Figure 3.
Armillaria obscura mushrooms growing from
the base of an infected Douglas-fir.



Figure 4.
Armillaria obscura mycelium on the roots
of a living Falsebox plant (Paxistima myrsinites).



Figure 5.
Laminar decay of a stump typical of Phellinus weirii.



2.0 ABOVE GROUND SYMPTOMOLOGY PRODUCED BY ROOT DISEASES

2.1 Conifers:

Root diseases typically attack and kill the roots of trees. This action causes disruption of water and nutrient uptake and can result in decline and death of the tree. The symptoms of root disease attack are therefore declining or dead trees. Decline symptoms are similar for both Armillaria obscura and Phellinus weirii. They are:

- A. Reduced leader growth leading to rounded crowns.
- B. Chlorosis (or yellowing) of the foliage.
- C. Thinning of the crown.
- D. Death.

While these symptoms are listed in the order in which they usually occur, this order can vary somewhat. Advanced symptoms can occur prior to or without the expression of any light infection symptoms. Very small conifers (< 2m) commonly experience 'flash kill'. Flash killed trees die rapidly, commonly without any needle loss or leader reduction in evidence. Flash kill is rare in larger conifers.

2.2 Falsebox:

Armillaria infection causes mortality of all or part of the infected bush. In many cases, healthy green, red leaved and long dead branches can all be found on one plant. Confirmation of Armillaria obscura requires uprooting the plant and examining beneath the bark of the roots near the root collar (see Identification of Root Diseases).

2.3 Other Hardwoods:

Table 2 lists the other hardwoods found to be susceptible to A. obscura attack in FRDA Research Project 3.8 (1986/87). Symptoms in hardwoods include chlorosis, leaf loss and death. Root excavations are required to reveal the presence of A. obscura mycelial fans.

Figures 10 to 30 illustrate the various symptoms produced in root disease infected trees and shrubs. Figures 8 to 13 deal with young conifers (< 10 years), Figures 14 to 23 show A. obscura on hardwood species. Figures 24 to 30 show symptoms produced on older root disease infected conifers.

2.3 Root Disease Centers:

Both A. obscura and P. weirii spread primarily by contact between healthy and infected roots. This tends to produce root disease 'centers'. Two types of centers are described in RD 001 and RD 002. These are illustrated in Figures 6 and 7. Classic infection centers require time to develop and are

therefore usually restricted to older stands. Advance regeneration of susceptible species and trees of resistant species commonly occur within the central cleared area. Diffuse centers occur in both old and young stands. The boundaries of such centers are difficult to distinguish, thus only rough approximations of the size of such centers can be made.

Table 2.

Hardwoods affected by A. obscura.

- Baldhip rose (Rosa gymnocarpa Nutt.)
- Bebb's willow (Salix bebbiana Sarg.)
- Big huckleberry (Vaccinium membranaceum Doug. ex. Hook.)
- Birch leaved spirea (Spirea betulifolia Pallas)
- Black cottonwood (Populus balsamifera L.
ssp. trichocarpa Brayshaw)
- Common paper birch (Betula papyrifera Marsh)
- Falsebox (Paxistima myrsinites (Pursh) Raf.)
- Red stemmed ceanothus (Ceanothus sanguineus Pursh)
- Saskatoon (Amelanchier alnifolia Nutt.)
- Sitka alder (Alnus viridis ssp. sinuata
(Regel) Love and Love)
- Soopolallie (Shepherdia canadensis (L.) Nutt.)
- Utah honeysuckle (Lonicera utahensis S. Wats.)

Infection Center Types

Figure 6: Classic Infection Center.

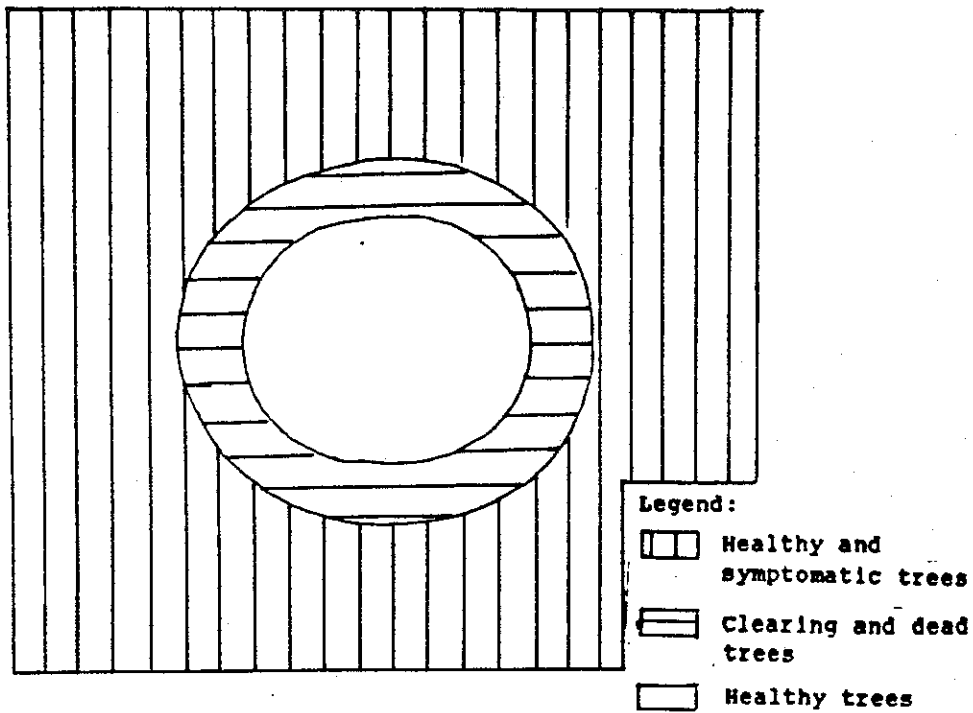


Figure 7. Diffuse Infection Center.

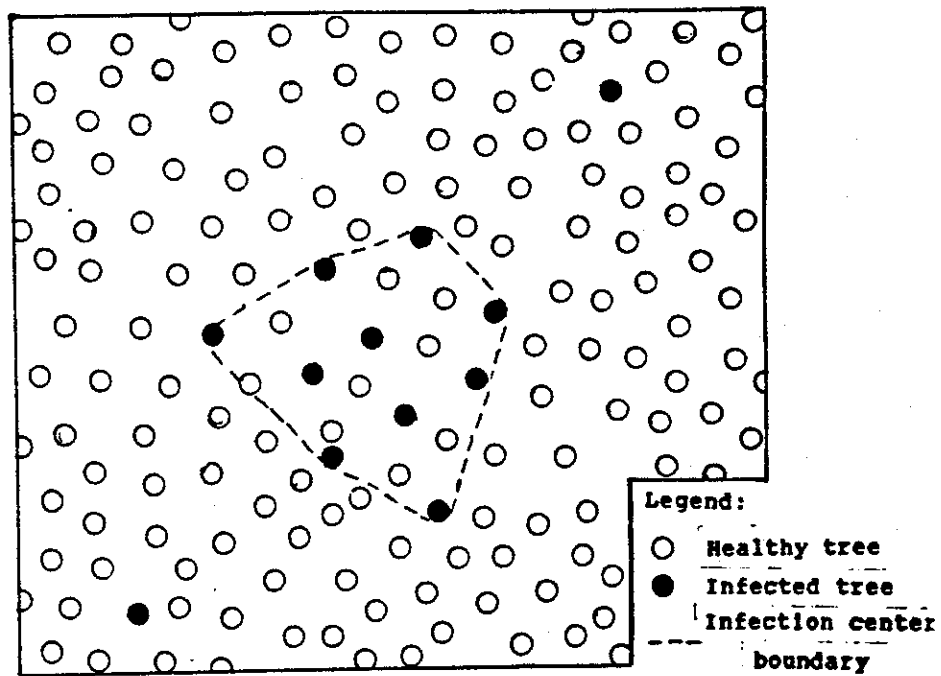




Figure 8. Above ground symptoms of root disease in young *Pseudotsuga menziesii*. Progression through the symptoms from right to left: Healthy, Lightly Symptomatic (chlorotic), Severely Infected and finally Dead.



Figure 9. Root disease infection center in 4 year old Pine plantation. Note the small size of the tree at the far right. This tree was killed >1 year prior to this photo being taken. The other two trees were killed in the current year.

Figure 10 (right). Root disease induced mortality in Western white pine (Pinus monticola). Note the stress crop of cones produced.

Armillaria obscura was the causal agent.



Figure 11 (left). Root disease induced mortality in Cedar (Thuja plicata).

Armillaria obscura was the causal agent.



Figure 12 (right).
Armillaria obscura on
Spruce (Picea glauca X
engelmannii).



Figure 13 (left). Severely
infected naturally
regenerated Hemlock
seedling. The dead
Falsebox in the foreground
and the chlorotic Douglas
fir seedling at left were
also found to be infected
with Armillaria obscura.

Figure 14 (right).
Falsebox (Paxistima
myrsinites) partially killed
by Armillaria root disease.



Figure 15. Falsebox mortality due to Armillaria. The pine
at right was also infected and was partially girdled at the
root collar by mycelium.

Figure 16. (right)
Common paper birch
(Betula papyrifera) killed
by A. obscura.

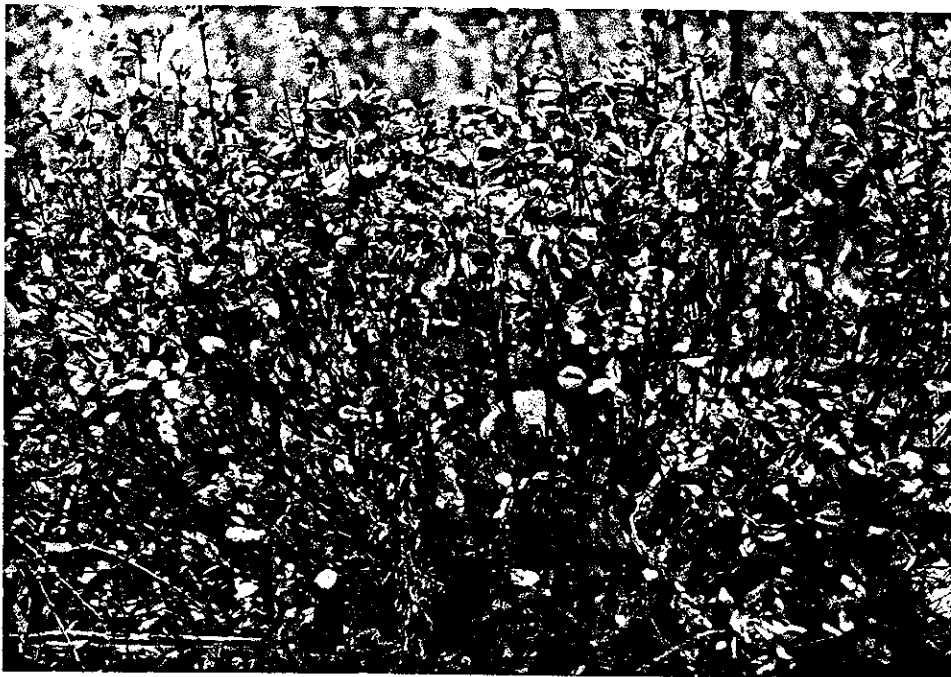


Figure 17.
Utah honeysuckle (Lonicera utahensis) killed by A. obscura.



Figure 18.
Big huckleberry (Vaccinium membranaceum) infected
with A. obscura.



Figure 19.
Soopolallie (Shepherdia canadensis) infected with
A. obscura.



Figure 20.
Redstemmed Ceanothus (Ceanothus sanguineus) partially
killed by A. obscura.

Figure 21. (right) Bebb's
willow (Salix bebbiana)
infected with A. obscura.





Figure 22.

Sitka alder (Alnus viridis ssp. sinuata) killed by A. obscura. This plant was part of a disease center which contained infected Cedars, Spruce and Pine.



Figure 23.

Birch leaved spirea (Spirea betulifolia) infected with A. obscura

Figure 24 (right). Infected Douglas-fir (center) showing thinned crown and chlorosis.



Figure 25 (below).
Heavily infected and dead Douglas firs
(approximately 15 years old).



Figure 26 (right). Infected Douglas-fir showing rounded crown (caused by reduced leader increment).



Figure 27 (left). Severely infected Douglas-fir showing crown thinning and chlorosis.



Figure 28
Symptoms of root disease
in Cedar. Note extremely
thinned crowns.



Figure 29 (right). Medium infection levels in mature Lodgepole pine.



Figure 29. Lodgepole pine showing various stages of infection:
 A. Light symptoms, crown rounding
 B. Medium symptoms, crown thinning C. Heavy infection.

3.0 PLANTATION SURVIVAL SURVEY, FREE TO GROW SURVEYS

Root disease infected plantations under ten years of age generally show low levels of infection (< 5%). However, only the current or last years mortality is readily detectable. As well, even low infection levels in plantations represent potentially serious losses if continued throughout the rotation. Thus, it is important that surveys for root disease in these plantations be of sufficient intensity to detect low infection levels. Knowledge of root disease incidence at this age is important in predicting future crops and in assessing licensee responsibilities for establishment of free growing plantations.

Detection of obvious root disease symptoms during the initial reconnaissance of the block should initiate the root disease survey. The proposed survey consists of strips of trees, corresponding to 2-3 planting lines each. The strips are run parallel to each other at 100m intervals. The number of planting lines within each strip depends on the spacing of the trees, where trees are more than 2 m apart, two planting lines are included. Where the spacing is less than 2 m, three lines are included. In this way a sampling intensity of 4-5% is assured. This intensity should be sufficient to assess the root disease incidence in the block. Where planting lines are unclear or the site was naturally regenerated, 5 m wide strips at 100 m intervals along a baseline should be used. In this case the stocking level of the cutblock must be estimated so that root disease incidence levels can be determined.

Within each strip the numbers of dead and symptomatic conifers are tallied per 100 m of strip. The trees are tallied as indicated on the survey card RD 002 (Figure 8). As well as dead and symptomatic conifers, spaces where trees should have been (judging from average spacing distances) are also examined. If no sign of the conifer remains, the spot is checked for the presence of A. obscura on any hardwood species present. Falsebox is quite susceptible to attack by Armillaria. As well, it is a common plant in many southern interior plantations and is generally well and fairly evenly distributed throughout the block. It is therefore a useful plant for assessing the presence of A. obscura root disease in planting spots which no longer contain a tree. It is important, however, that the distinction be made between parasitic and saprophytic Armillaria growth. Parasitic attack can generally be confirmed where the Falsebox plant is still partially alive or where the plant has recently been killed and girdling of the root collar by Armillaria obscura mycelium is observed (Figure 4). Where more than one Falsebox plant in the vacant planting spot is affected, parasitic attack need only be confirmed on one plant.

3.1 HOW TO COMPLETE THE RD 002 SURVEY CARD:

3.1.1 SIDE 1:

1. Planted Spacing or Stocking Level of Regen.:

Enter spacing between trees in planted blocks or an estimate of stocking level in naturally regenerated sites.

2. Strip #:

Enter the number of the strip currently being performed.

3. Length:

Enter strip length (generally 100 m unless modified to fit the dimensions of the block).

4. Infected Trees by Year:

Enter infected trees as a running tally. Mortality which has occurred within the last growing season and trees showing non fatal symptoms are noted separately. Mortality in previous years is recorded in the column labelled ->1 (for greater than one year ago). The date of death in plantations can be determined by counting the number of growth cycles (whorls) represented at the time of death. The final column (m), is for entering missing trees. Enter only those spots which appear to have had a seedling and which now contain signs of Armillaria obscura infection on natural conifer regeneration or hardwood species.

When surveying naturally regenerated sites, only the current years infections are specified as to date of mortality. All others are recorded simply as mortality which has occurred greater than one year prior. Empty spots are not tallied but may be mentioned under comments on side 2.

5. # Centers:

Enter the number of centers located as a running tally. Describe each center on side 2 of the card as it is encountered.

5b. Trees included:

Note the number of trees (as a tally) included within both the noted infection center and the survey strip.

6. Species Infected:

List the tree species found to be infected. Only potential crop tree species should be noted. List the most impacted species on the left, rarely impacted species on the right.

7. Diseases Present:

List the root diseases found to occur on the site. List the most common pathogen on the left and the rarest on the right.

8. Total all columns.

8b. Total number of infected trees from (8), (excluding total of (5b)).

9. Total Trees Surveyed:

For planting line oriented strips:

$$\text{Total trees surveyed} = \frac{\text{Total length of all strips (m)}}{\text{Spacing of trees (m)}} \times \text{\# planting lines/strip}$$

For 5 m wide strip method:

$$\frac{\text{Total length of all strips (m)} \times \text{strip width (5 m)}}{10,000 \text{ m}^2 / \text{ha}} \times \text{estimated stocking level (1) in trees/hectare}$$

10. For each year calculate % mortality using the equation:

$$\% = \frac{\text{Total of trees in year (8)}}{\text{Number of trees surveyed (9)}} \times 100\%$$

11. Total Reduction in Stocking (%):

Sum % mortalities (10).

12. Number of single tree infections:

Subtract total for (5b) from (8b).

13. Total infected spots:

Add (12) to the total number of centers in (8).

3.1.2 SIDE 2:

Site Diagram:

Indicate block outline, adjacent roads, water bodies, etc. with general layout of baseline and strips. Indicate position of strip lengths by number.

Center Descriptions:

Describe centers recorded in (5) on Side 1 as to:

- a) Strip number (same as (3) on page 1).
- b) Approximate position along strip length at which it occurred.
- c) Approximate size. Estimate the size (in square meters) of the center.
- d) Type: Record whether the center is diffuse (D) or classic (C) in form, using the descriptions below:

Diffuse:

Localized concentration of root disease losses. Dead and diseased trees interspersed with healthy ones. Infection

level must be significantly higher than surrounding area (Figure 7).

Classic:

Older, well expressed centers. They consist of a central area in which conifers of susceptible species are virtually absent and a surrounding ring in which losses to root diseases are very high. This type is not likely to be expressed in stands less than 15 years old. (Figure 6).

Site Notes:

Note presence of infection in stumps, relation (if any) between infection and old stumps, hardwoods infected, other pests present etc.