

**TRIAL OF A REGENERATION SURVEY MODIFIED
TO ASSESS ARMILLARIA ROOT DISEASE**

by

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FOREWORD

This report is one of a series of internal reports distributed by Forest Protection Branch, B.C. Ministry of Forests, to record accomplishments and interim or provisional results for the information of staff, colleagues, and others.

In the Canada-British Columbia Forest Resources Development Agreement (FRDA) 1985 to 1990, over 100 pest control projects were directly funded by the province and administered by protection staff. To facilitate application of the results, and development of improved forest health management strategies, the contractors reports have been edited and distributed as internal reports. Accordingly, any opinions and recommendations expressed are those of the contractor, and not necessarily those of the ministry or the FRDA management committee.

For details or more information about the report or project, please contact forest health staff at Protection Branch or at the forest region offices.

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The guidelines for internal reports outlined in the Protection Manual were adhered to as closely as possible. All manuscripts were altered to comply with a common format, but entire reports were not rewritten to conform to a standardized outline.

Most Executive Summaries were the work of Graham Hawkins of MoF Inventory Branch (formerly with Pacific Coast Forest Biology). All word processing was accomplished by Catriona Kaufman of Top Kat Services. Will Gordon of R. White Woods inc. prepared all maps and figures.

R. White, editor
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EXECUTIVE SUMMARY

A total of 1 088 regeneration survey plots were established in 1 321 ha (16 openings) in the Golden TSA. All normal regeneration survey procedures were used to standard specifications except that data on *Armillaria* root disease were also collected within plots and between plots. A 100m grid was employed to assure adequate coverage. Causal agents were confirmed for all infected trees. *Armillaria* was previously unrecorded in all openings.

Of the sites surveyed, 81% had confirmed or suspected *Armillaria*. Ten blocks (63%) were confirmed for the disease and six blocks (38%) had high infection levels where NSR conditions can be anticipated. Infection was also noted in stands adjacent to some of the infected blocks. It was established that approximately two-thirds of the blocks sampled will be at risk by rotation age. Black stain root disease was found on Douglas-fir and lodgepole pine. Root collar weevils and various stem rusts were recorded on lodgepole pine. Frost, rodent damage and gall aphids were widely noted.

Identification of *Armillaria* root disease within regeneration plots was feasible when crown symptoms were present. Accuracy was affected by the occurrence of non-symptomatic trees; thus, the estimated number of *Armillaria*-infected trees per plot was below actual levels. Recording the disease between plots was possible but decreased survey productivity by 10 to 15%. Measuring *Armillaria* root disease between plots was considered to be inaccurate due to the occurrence of brush and non-symptomatic trees. Numbers of trees recorded between plots could not be used for estimates because of missed trees and variations in infection centre distances. The cost of incorporating *Armillaria* data gathering into a standard regeneration survey was found to be negligible.

The following recommendations resulted from this project:

- *Armillaria* root disease should only be noted and mapped between plots and should not be quantified. Mapping will provide information, not disease distribution for treatment purposes. Disease incidence should only be estimated within plots.
- Information on *Armillaria* root disease should be incorporated into standard regeneration/free-to-grow surveys.
- Stands should not be assessed as free-to-grow if *Armillaria* root disease levels exceed five contaminated spots per hectare or one or more percent of the plots.
- Contaminated growing spots per hectare should be used to measure disease levels within plots because this criterion is easily assimilated into the survey and gives a good description of disease intensity.

- Examine each block for residual timber and determine infection levels in these by means of a walk-through.
- Conduct stand development estimates in each block examined using root disease models.

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1 INTRODUCTION

In the summer of 1987, Laing and McCulloch Forest Management Services was contracted to conduct a combination *Armillaria* root disease and regeneration survey of 16 openings in the Golden Timber Supply Area (TSA).

The purpose of the survey was to:

1. test the feasibility of incorporating *Armillaria* root disease (DRA) data collection into standard regeneration-free growing surveys;
2. determine the extent or incidence and intensity of DRA in blocks, where it was not recorded in the Silviculture History Record System;
3. determine if there were correlations between DRA incidence and ecosystems, site productivity, or other pest problems;
4. determine, by comparison of infection results in regeneration to infection from the previous or adjacent stands, what threshold levels of infection are deemed "acceptable."

2 METHODS

Sixteen blocks, in need of regeneration surveys due to time since logging, were chosen from the MoF History Records. The blocks were chosen on the basis of logistics of surveying and to obtain a wide coverage of the Golden Forest District.

All surveys were to be done to normal silviculture survey specifications. Sharon Moss of the Golden Forest District, Pest Management Section, supervised and performed quality control checks. Because this was a pilot project, quality was emphasized.

The contractors selected had a good general background in surveys and pest identification and only one day was required to familiarize them with specific identification of symptoms of root disease (in both trees and falsebox shrubs), other pests, and ecosystem identification.

Normal survey procedures were followed with three exceptions:

1. In the survey summary card (FS 659) contaminated growing spots were calculated separately and recorded under a slash for well-spaced, free-growing and plantable spots (e.g., 293/3 plantable spots/ha means 293 plantable spots/ha, of which three spots/ha are contaminated with *Armillaria*).
2. Upon entering a plot, any *Armillaria*-contaminated spot, dead or dying tree, or symptomatic tree was located. The first one seen became the first growing spot and all measurements/estimates were based on that starting point. This prevented the "fitting" of trees around a contaminated spot as would normally happen with a large obstacle found within a plot.
3. Records of *Armillaria* were kept for those areas between the plots, to provide a perspective of the extent of the infection and as a check to determine if significant *Armillaria* infections were being missed by plots.

Armillaria was recorded on the cards (FS 657 and FS 658) under the species column as "5/1," which means five trees of that species in the plot were well-spaced, one of which had *Armillaria*.

Plantable spots contaminated with *Armillaria* were identified by:

1. "old" dead conifer seedlings with mycelial fans;
2. presence of infected shrubs (mainly falsebox);
3. infected stumps or residual trees.

Group V *Armillaria* (*Armillaria sinapina*) does not generally kill conifer trees; therefore, all trees killed/infected by *Armillaria* were assumed to be *Armillaria ostoyae*. Trees killed by other agents and then infected by Group V were distinguished due to prolific production of rhizomorphs.

Plots were generally surveyed on a 100m x 100m grid to ensure that each opening was thoroughly and completely sampled.

Although the surveyors were only asked to note DRA between plots, in fact, they examined most symptomatic trees and attempted to confirm the infection or establish the causal agents. The resulting pest identification between plots is therefore reliable.

3 RESULTS

Of the 16 units surveyed in which DRA was previously unrecorded, 13 (81%) had DRA confirmed or suspected. Ten blocks (63%) had a DRA infection confirmed, and of these, six blocks (38%) have a significant level of infection where plantation failures or poor stand development (i.e., high yield losses) may be anticipated. Table 1 provides a summary description of the blocks examined and their problems - potential or existing. Infection status of blocks and ecosystem association by infection status are shown in Table 2.

Black stain root disease (*Leptographium wageneri*) on both lodgepole pine and Douglas-fir were found. Warren's root collar weevil (*Hylobius warreni*), spruce weevils and various lodgepole pine stem rusts were also noted. Spruce gall aphid (*Adelges cooleyi*), which alternates between Douglas-fir and spruce species, was evident everywhere Engelmann spruce and Douglas-fir seedlings grew together. Frost and rodent damage were also prevalent. These agents as tree stressors may enhance DRA in low DRA-infected sites.

There appears to be a sharp division between Group B and Group C in terms of infection levels.

Groups A and B had similar levels of plots infected, but Group A units did not contain more than 1.6% of DRA suspect plots. Group B units averaged about one confirmed infected growing spot per hectare, and contaminated growing spots between plots were noted. The highest recorded infection rate was three growing spots per hectare in one strata in Unit 9.

Group C units tended to have more than 10 growing spots per hectare infected with DRA, and Group D had in excess of 15 spots per hectare.

Within both Group C and D, some regenerated stands had adjacent forests with DRA infection. Of the five blocks in these groups, two had "original" stands immediately adjacent. DRA infection exceeded 10%, based on walk-through examination. In discussion with Evans Products Company Ltd., the major licensee in the Golden TSA, the other blocks were thought to have had noticeable infections that, at the time of cruising and logging, were not recognized for the hazard to forest management the disease posed. In any case, it is probable, but can not be documented, that the original stands had infection levels over eight percent. Based on the five times rule,¹ this means that 40% of the trees had infected root systems. If this is true, yield losses approaching 50% may be anticipated.

¹ Filip, Gregory M. 1986. Symptom expression of root-diseased trees in mixed conifer stands in central Washington. Western Journal of Applied Forestry. 1(2): 46-58; 1986.

Data are lacking on previous stand infection rates in Group A and B stands, and therefore no conclusions can be reached.

The contractor made the following observations:

1. Identification of *Armillaria* root disease during a regeneration survey is possible and easy when trees exhibit classic symptoms. Unfortunately, it is not possible to estimate how many *Armillaria* root disease spots were missed due to unexpressed symptoms of the disease.
2. Some trees showed symptoms of *Armillaria* root disease but no resinosis or mycelial fans were found. These trees may or may not have *Armillaria*, and subjective judgement was used to decide whether to call it an infection spot or not.
3. Recording *Armillaria* trees between plots was possible but difficult, especially when in brushy strata, or where the trees had died from *Armillaria* a few years ago, and were missing or lying on the ground.
4. The numbers of trees recorded between plots cannot be used for estimations of *Armillaria* infections, as the distance from the survey line that the trees were noted varied between and within units, and trees were easily missed.
5. Because identifying *Armillaria* trees between plots is less useful in terms of hard data and because this is the part of the *Armillaria* portion of the survey which took the most time (going to each suspect tree to check it for resinosis or mycelia), it is recommended that this be dropped in future, although *Armillaria* presence between plots still be noted but not counted.

TABLE 1 SUMMARY DESCRIPTION OF BLOCKS EXAMINED

UNIT	SITE CLASS* EP MAP	OTHER PROBLEMS	STOCKING (ha)	AGE (Range)	COMMENTS
1, 4, 5, 6, 14, 19, 20	G M	Brush, rodents, frost, aphids, browsing, (PI & Fd) blackstain, Warren's root collar weevil	SR 341 NSR 69 FG 44 Wrong species - 9	6-16	Early for site class deter- mination. Check history records for previous stand data.
3, 7, 9	G P/M	Brush, rodents, PI rusts, DRA, Fd frost forking	SR 135 NSR 25 FG 8	11-17 (3-8)	Block 9 = 3-8 years: early for DRA to be expressed. Picked up 1 strata with DRA. DRA, where found, was scattered: 3 spots/ha; 1 tree mortality.
11, 18	G P	Brush, aphids, Warren's root collar weevil, (F) blackstain, spruce weevil, DRA	SR 106 NSR 25	8-14	DRA scattered to patchy found along strips and in plots. DRA is in most of root systems of previous stand.
2, 8, 10, 15	G P	DRA, (F) blackstain, brush, aphids, browsing, rodents	SR 527 NSR 63	8-13	Obvious DRA damage, pro- bable plantation failure and stand tending problems.

* Age of seedlings precludes site class measurements at time of survey.

The units were separated into four groups, based on the percentage of growing spots infected with DRA, as shown in Table 2. The comments section of Table 1 reflects the growing incidence of DRA.

The above group has potential stressors that may enhance an apparently low level of DRA that is presently scattered throughout blocks.

TABLE 2 BLOCK SUMMARIES BY INFECTION CLASS AND ECOSYSTEM ASSOCIATION

Parameter	Infection Classes			
	A	B	C	D
Percentage of Growing Spots Infected	(<0.1)	(0.1 - 0.5)	(0.5 - 1.0)	(>1.0)
Unit	1, 4, 5, 6, 14, 19, 20	3, 7, 9	11, 18	2, 8, 10, 15
Total ha	462.5	168	131	590
Percentage of Plots Infected	0.7	0.6	2.4	4.7
Growing Spots/ha Contaminated	0	1	10	15+
Ecosystems	ICHa ₂ -3(5) ESSFa-3(1)	ICHa ₂ -3(4, 1)	ICHa ₂ -3(1, 4)	ICHa ₂ -3, 1
Previous Stand	DRA infection unknown	DRA infection unknown	10%+ DRA An unacceptable level of stand infection	10%+ DRA

4 CONCLUSIONS AND RECOMMENDATIONS

The consultant found that the cost to the regeneration survey of doing additional root disease assessment was negligible and was simple to incorporate. Thus, the method used to collect and record pest data is recommended.

Other conclusions are:

1. None of the blocks were recorded in the History Record as having DRA problems, yet almost 40% of the blocks are facing plantation failure and another 20% are at some level of risk. Thus, all future regeneration surveys should incorporate *Armillaria* infection information. This together with a concentrated effort to accurately upgrade History Records with regard to pests will ensure appropriate planning and treatments are used district-wide.
2. *Armillaria* observed between plots should be recorded to provide an idea of disease distribution within the block or within infected strata. Only observations are necessary (with an occasional tree root collar examination) to verify infection. Other pest problems should also be noted.
3. Stands with more than five contaminated spots per hectare or with one or more percent of plots with infection should not be considered as free-growing. With more experience this parameter may be further reduced, but will not likely rise.

Categorization of DRA infection in regeneration stands should use the "contaminated growing spots/ha" rather than percentage of plots infected because:

- (a) it is a better description of disease intensity;
 - (b) it relates to spots/ha that other silvicultural data are summarized;
 - (c) this ensures that the surveyors must "look for" DRA in each spot in each plot; and
 - (d) spots/ha is not related to sample intensity and is much easier to estimate in walk-through type of surveys.
4. The method of using regeneration plots to quantify estimates of disease is valid, simple and useful; thus, regeneration surveys and free-growing procedures should be modified as per the methods section of this report.
 5. Examine each block surveyed for patches of residual timber or advanced stand development (i.e., greater than 30 years) and determine infection levels via a walk-through survey. If correlations with infection in plantations seem possible, conduct a line intercept plot survey in those residual stands to quantify infection levels, so that treatment options may be evaluated.

6. When Prognosis, Stand and Root Disease models become available, conduct a series of stand development estimates in each block examined. Compare the results of no treatment versus treatment for root disease, and report the results.

TABLE 3 **COMPARISON OF EA (ECOSYSTEM) SITE CLASS AND MAP (INVENTORY) SITE CLASS**

UNIT	OPENING NUMBER	STRATUM	ECOSYSTEM	MAJOR SPECIES	SITE CLASS INVENTORY	SITE CLASS ECOSYSTEM
1	82N 054-43	A	ICH a2-3	Fd	P-G	G
		B	ICH a2-3	Fd	M	G
		C	ICH a2-3	Pl	M	M/G
		D	ICH a2-3	Fd	P	G
		E	ICH a2-3	Se	M	G
2	82N 054-50	A	ICH a2-3	Fd	P	G
		B	ICH a2-3	Fd	P	G
		C	ICH a2-3	Fd	P	G
3	82N 054-39	A	ICH a2-3	Fd	M	G
		B	ICH a2-3	Pl	M	M/G
		C	ICH a2-3	Fd	M	G
4	82N 054-42	A	ICH a2-3	Fd	M	G
		B	ICH a2-3	Se	M	G
5	82N 054-56	A	ICH a2-3	Fd	P	G
		B	ICH a2-3	Fd	P	G
		C	ICH a2-3	Pl	P	M/G
		D	ICH a2-3	Se	P	G
		E	ICH a2-3	Pl	P	M/G
6	82N 054-59	A	ICH a2-3	Fd	M	G
		B	ICH a2-3	Se	M	G
		C	ICH a2-5	Fd	?	-
7	82N 054-45	A	ICH a2-4	Fd	P	G
		B	ICH a2-3	Fd	P	G
8	82N 054-60	A	ICH a2-3	Fd	P	G
		B	ICH a2-3	Fd	P	G
		C	ICH a2-1	Se	P	G
		D	ICH a2-3	Pl	P	G
		E	ICH a2-3	Se	P	G
9	82N 064-21	A	ICH a2-1	Fd	P	G
		B	ICH a2-1	Fd	P	G
		C	ICH a2-1	Fd	P	G
		E	ICH a2-1	Se	P	G
10	82N 064-30	A	ICH a2-3	Fd	P-M	G

**TABLE 3 COMPARISON OF EA (ECOSYSTEM) SITE CLASS AND MAP
(INVENTORY) SITE CLASS**

UNIT	OPENING NUMBER	STRATUM	ECOSYSTEM	MAJOR SPECIES	SITE CLASS INVENTORY	SITE CLASS ECOSYSTEM
11	82N 064-2	A	ICH A2-3	Fd	P	G
		B	ICH A2-3	Fd	P	G
		C	ICH A2-3	Se	P	G
14	82N 063-14	A	ICH a2-3	Fd	P-M	G
15	82N 073-1	A	ICH a2-1	Fd	M	G
		B	ICH a2-1	Fd	M	G
18	82N 044-21	A	ICH a2-1	Fd	P	G
		B	ICH a2-4	Fd	P	G
		C	ICH a2-1	FdSe	P	G
19	82K 100-106	A	ESSF a-1	Fd	M	P
		B	ESSF a-1	Fd	M	M
		C	ESSF a-1	Fd	M	P
		D	ESSF a-1	Se	M	M
20	82N 009-44	A	ESSF a-3	Fd	G	M
		B	ESSF a-3	Fd	G	M
		D	ESSF a-3	Fd	G	M