

TASK FORCE REPORT ON ROOT
DISEASE RESEARCH

by

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"A Report Prepared for the Forest Pest Review
Committee of British Columbia"

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PREFACE

A task force initiated by the Forest Pest Review Committee of British Columbia reviewed current research programs on forest tree root diseases in B.C., Canada and northwestern United States.

The task force found that relatively little work and expenditures were directed to root disease research, even though root diseases were recognized as very important, and were expected to increase in importance with more intensive management of forest stands.

The task force recommended that the Forest Pest Review Committee should advise both the Federal and Provincial governments of the serious and increasing threat of root diseases to forest productivity, and urge that additional funds and staff be allocated to research and development of appropriate control measures.

Comments or questions about this report are welcomed, and should be directed to the Chairman, Forest Pest Review Committee, c/o Protection Branch, Ministry of Forests and Lands.

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TASK FORCE REPORT ON ROOT DISEASE RESEARCH

1. PURPOSE

The Forest Pest Review Committee of British Columbia requested Dr. R. Strang, Forest Research Council, to initiate a task force on forest tree root disease research in B.C. The objectives of the task force were to review current research programs on root disease, in B.C. and elsewhere and to outline research needs for B.C. forests. We thank the government groups and agencies that kindly responded to our inquiries and recommendations.

The findings of the task force plus outlines of current research on root diseases are presented in this report.

2. REVIEW OF CURRENT RELEVANT RESEARCH IN B.C.

The only comprehensive root disease research program in B.C. is conducted by the Canadian Forestry Service (C.F.S.), Pacific Forest Centre, Victoria. The program includes 2.4 person years for scientists, 4 for technicians and 1 for a forestry officer. Funding (1985-86) included \$34,000 for operations and capital expenditures and approximately \$225,000 for salaries. Research projects for root diseases included epidemiology, impact, control methods and technology transfer. Pathogens included Phellinus weirii and Armillaria ostoyae with a few projects on Heterobasidion annosum and Ceratocystis wageneri. Recent project and study statements are appended (Appended 2). To date, most work has been conducted in coastal forests.

The remaining organizations in B.C. have conducted a few short term projects. Dr. B. J. van der Kamp and associates, University of British Columbia, have completed two projects on Inonotus tomentosus.

The Ministry of Forests and Lands has conducted a few projects, mostly on survey methods, in co-operation with the C.F.S. under the Forest Research and Development Agreement. Several control trials, mostly demonstrations, have been established in cooperation with C.F.S. researchers. One research project to determine the effect of fertilizing on Armillaria root disease was established near Kamloops. The Ministry has not designated staff nor program expenditures for root disease research at Research Branch, Victoria or at Regional Offices.

Only a few, limited, root disease research studies have been undertaken by industry. Canadian International Paper has recently proposed to investigate the effects of glyphosate (herbicide) for spacing in infected stands. J. Kumi of MacMillan Bloedel Ltd., is studying tissue cultures as a means of screening trees which are resistant to root rot.

3. REVIEW OF CURRENT RELEVANT RESEARCH OUTSIDE B.C.

3.1 CANADA

Maritimes	C.F.S. may institute <u>Armillaria</u> projects (Dr. R. Wall) if the problem in plantations there increases. Univ. of New Brunswick is not doing any work in this area.
Ontario	C.F.S. has an <u>Armillaria</u> project (Dr. R. Whitney and J.T.M. Dumas) studying the genetics and biological control components particularly. Univ. of Toronto (Dr. M. Hubbes) is also working on the incidence and biology of <u>Armillaria</u> .
Prairies	C.F.S. - Dr. Y. Hiratsuka leads a team, with Dr. P. Blennis (Univ. of Alta) exploring the ecology, distribution and occurrence of <u>Armillaria</u> in plantations.

3.2 NORTHWESTERN UNITED STATES

Although a few short term research studies have been conducted by the States of Washington and Oregon, most of their projects have been directed to extension and to facilitating control operations. Similarly, the U.S.D.A. Forest Service, Pest Management, Portland, has undertaken a few short term research studies (called "administrative" studies), but most of their work is directed to surveys and extension. A recent list of U.S.D.A. research priorities for the Pacific Northwest is appended (Appendix 3). Root diseases are considered to be the most important problem.

4. RESEARCH NEEDS IN B.C.

As shown in Table 1, root diseases were considered to be important. They were rated by priority for investigation as:

- H - high
- M - moderate
- L - low, and
- W - worthwhile, basic science.

Topics for research per disease were grouped in five topics:

1. Biology, including the infection process of the fungus
2. Site ecology, risk or hazard
3. Tree susceptibility, resistance, killing, tolerance
4. Methods of survey and damage appraisal
5. Control measures

An elaboration of this list of topics is appended (Appendix 1)

TABLE 1 PRIORITIES AND TOPICS FOR RESEARCH ON ROOT DISEASES
IN BRITISH COLUMBIA

Root Disease 1, 2	Coast	Region	
		N. Interior	S. Interior
laminated root rot	H 5	L	H 2,5
armillaria root disease	L	L	H 2, 3, 4
tomentosus root disease	L	H 4, 5	M 4, 5
annosus root disease	M 2	L	L
blackstain root disease	W 1	L	M 2

- Notes: 1. These five root diseases are listed in order of importance.
2. Root disease fungi for the diseases are Phellinus weirii,
Armillaria obscura, Inonotus tomentosus, Heterobasidion annosum and
Ceratocystis wageneri.

5. FUNDING FOR RESEARCH AND ESTIMATES OF FOREST LOSSES

Data assembled by the Forest Research Council shows relatively small expenditures by all research agencies on forestry pathology research.

TABLE 2. FOREST RESEARCH ALLOCATIONS BY AGENCY
IN BRITISH COLUMBIA

Agency	1985/86 Expenditure	Allocation to Protection		
		Fire	Insects	Diseases
Pacific Forest Centre C.F.S.	\$7,200,000			\$259,000 = 3.6%
B.C.F.S., Research Br.	\$6,367,770	nil	nil	nil
Regional Res.	\$2,413,265))		\$24,133 = 1.0%	
Universities				
S.F.U.	\$538,187)		\$398,258 = 74.0%	
U.B.C.	\$2,282,516)	\$95,865 = 4.2%	\$79,888 = 3.5%	\$59,345 = 2.6%
Science Council of B.C.	\$1,482,000		\$75,582 = 5.1%	
Industry			\$13,200	\$52,849

Annual losses based on C.F.S. estimates reported in the 1984-85 Annual Report of B.C. Forest Service are:

to fire 49 000 ha (10 yr. average)
to insects 15,000,000 m³
to diseases 17,000,000 m³

- dwarf mistletoes 3,338,000 m³
- root diseases 3,440,000 m³
- decay 10,000,000 m³

Three groups of pathogens cause most of the losses in B.C. -- decay fungi, dwarf mistletoes and root disease fungi.

6. CONCLUSIONS

As overmature stands are felled, losses to decay will diminish. Adequate management responses to dwarf mistletoes are available. Therefore, root diseases command the greatest interest. However, there are many gaps in our knowledge about root diseases, and control measures or management responses are lacking. We anticipate an increase in root disease losses in second-growth or managed stands unless suitable control measures are applied.

A recent estimate puts current losses to laminated root rot in coastal B.C. at 10 - 15% of the area of second-growth Douglas-fir and Douglas-fir - western hemlock stands between 40 and 80 years old. This could rise to 20% by 2000, entailing an annual loss of stumpage revenue of \$10,000,000, at today's rate. In northern and interior B.C. losses to *Armillaria* root disease and *tomentosus* root disease are conjectural but are known to be substantial and increasing.

At least part of the reason for an expected future expansion of infestation by root rots is the modern practice of prompt planting of a cutblock with trees of the same species. Formerly, after catastrophic clearing, natural succession led to colonization by other species which are not hosts to the root-rotting fungi and so loci from which infections might develop were much reduced before the susceptible crop trees became re-established. Truncating and telescoping the natural successional series by 'silviculture' fosters extension of the root diseases.

Apart from stump excavation, which is of limited applicability, we do not have adequate control techniques or management responses, and yet we continue the silvicultural process of prompt re-establishment.

It is apparent then that an enhanced effort to comprehend and then control root diseases is necessary, and there should be additional effort not simply transfer of staff and field study funds from other topics. It is important that any additional staff made available for this important topic be given appropriate technical and logistic support if they are to be enabled to make a significant contribution to our forest resource management capability.

7. RECOMMENDATION

The Task Force made the following recommendation:

THAT the Forest Pest Review Committee inform both the federal Minister of State for Forestry and the provincial Ministry of Forests and lands of the serious and increasing threat to forest productivity which is posed by the spread of root diseases of conifers, and urge that additional funds and staff be allocated to root disease research and to development of appropriate control measures and management responses.

APPENDIX 1

DETAILS ON FOREST PATHOLOGY RESEARCH TOPICS

1. Biology including infection process
 - 1.1 Identification of pathogenic strains, isolates, subspecies (vs. saprophytic, low-virulence, etc.)
 - 1.2 Spore infection and vector association
 - 1.3 Survival on and in roots and stumps (in relation to contact and penetration)
 - 1.4 Initial contact, infection, ectotrophic growth of mycelium on roots, internal colonization in relation to host and environmental factors
 - 1.5 Effects of temperature, soil moisture nutrients, associated microorganisms, fertilizers, fumigants, site (etc.), on infection phenomena
 - 1.6 Bio and histochemical processes during infection and colonization (critical or limiting steps in infection)
 - 1.7 Penetration and infection of above - ground scars and wounds
 - 1.8 Predisposition of trees to penetration and infection
 - 1.9 Colonization of partially colonized trees after cutting and other treatments
 - 1.10 Root extension (growth) and initial contact with inoculum
 - 1.11 Mycorrhizae and infection phenomena
2. Site ecology, risk, hazard
 - 2.1 Incidence and infection phenomena (1, 3) in biogeoclimatic zones, subzones, associations, and edatopes
 - 2.2 Ecological and site factors limiting infection
 - 2.3 (See 1.5)
 - 2.4 Management effects on disease - site interactions
 - 2.5 Rate of inoculum deterioration
 - 2.6 Suppression soils
 - 2.7 Infection center expansion or atrophy
 - 2.8 Rate of tree killing

3. Tree susceptibility, resistance, killing, tolerance
 - 3.1 Identification and screening of trees that appear more resistant (less susceptible) to damage
 - 3.2 Identification of basic mechanisms conferring increased resistance
 - 3.3 Selection and breeding more resistant trees
 - 3.4 Determination of "average" rates of infection, mycelial growth, tree killing, internal decay
 - 3.5 Screening of tree resistance in relation to site, soil, environmental, and associated biological factors
 - 3.6 Influence of tree age
 - 3.7 Adventitious and other root growth in relation to infection, etc.
 - 3.8 Management effects - spacing, thinning, partial cutting
 - 3.9 Mixed species stands
 - 3.10 Windthrow
4. Methods of surveys and damage appraisals
 - 4.1 Identification and ground detection
 - 4.2 Aerial photography to detect killed and diseased trees
 - 4.3 Detection in overmature - decadent stands
 - 4.4 Detection in 1-10 year old plantations
 - 4.5 Detection with multiple pests, mixed tree species, stand entries and other disturbances
 - 4.6 Damage due to reduced tree growth, mortality, and brush invasion
 - 4.7 Compensatory growth of residual stems
 - 4.8 Incorporation of damage data into forest yield models to project or assess damage impacts
 - 4.9 Remote sensing techniques

5. Control Measures (including efficacy, cost-benefit analyses, projections (models), and types of control such as biological, chemical, mechanical and silvicultural)

5.1 Alternate tree species

5.2 Stump and root removal - mechanical
- blasting

5.3 Trials of known chemical control techniques

5.4 Development of biological control techniques

5.5 Techniques for control during spacing and partial cutting

5.6 Mixed tree spp stands

5.7 Deciduous assoc. trees and ground cover (lupine?)

5.8 Site and ecological effects

5.9 Fertilization

APPENDIX 2

Your File Votre référence

Our file Notre référence 1165-36/B19



Government
of Canada

Gouvernement
du Canada

Canadian
Forestry
Service

Service
canadien des
forêts

Pacific Forestry Centre
506 West Burnside Road
Victoria, B.C. V8Z 1M5

Phone: (604) 388-0600

March 27, 1986

Dr. John Muir,
Protection Branch,
B. C. Ministry of Forests,
1450 Government Street,
Victoria, B. C.,
V8W 3E7.

Dear John:

Further to our telephone conversation, PFC resources allocated to research on root rots include 2.4 scientists, 4 technicians and 1 forestry officer. The funding for the project in 1985/86 consisted of \$9,100 in capital equipment and \$28,300 in operating and maintenance expenses. Total salaries for the project are confidential and thus not available. Please find enclosed copies of the 1985/86 project and study statements for details on objectives and goals. The forestry officer joined the root rot project this year through FRDA and will be responsible for technology transfer.

With respect to your question regarding allocation of human resources to root rot research, this area along with most others at PFC would benefit from increased resources. As the federal government is down-sizing, additional resources are not likely to be made available to PFC so any increase in the root rot project would come at the expense of some other area of research and none of our other research areas can afford to lose researchers. As a result, an increase in the allocation to root rot research is not appropriate at this time.

If you require further information, please feel free to contact me or Dr. Bloomberg.

Sincerely,

Gordon

Gordon Miller,
A/Program Director,
Forest Protection

GM/AI

Canada
cc: B. Bloomberg

RECEIVED

APR 2 1986

PROTECTION BR.
D.C.F.S. VICTORIA

Facs No. 34675

Telex No. 049-7147

CANADIAN FORESTRY SERVICE
Program Plan 1985-86

FORMAT III

PROJECT WORK PLAN

Page 1 of 6

1. Establishment & Location: Pacific Forest Research Centre Victoria, B.C.
2. Responsibility Centre: Forest Protection
3. Project Title and Number: Reduction of Root Disease Losses

PC-53

4. SA2/SA3 - Act: - 2400 - Forest Protection Research
2402 - Pest Biology Research

5. Project Leader: W. Bloomberg

6. Problem Definition:

Root diseases seriously reduce forest productivity in all forest zones of British Columbia. Each zone varies as to pathosystems which are peculiar to it and differ in their epidemiology, impact and management requirements. Eight different pathosystems have presently been identified. Whereas root diseases are part of the ecosystem equilibrium of virgin stands, they compete seriously with the forest manager for wood volume in second-growth, intensively managed stands. In addition to recouping these wood production losses in managed stands, reduction of root disease losses is a major opportunity to enhance forest productivity by ensuring that the gains achieved by intensive silvicultural and genetic improvement programs are not nullified. However, because of the wide range of pathosystems and geographic regions, the necessary research program to enable these gains to be realized must be as effective as possible within the limits of project resources.

7. Project Objectives:

- 7.1 To define the epidemiology of root diseases in British Columbia:

- 7.1.1. As a basis for developing controls.
- 7.1.2. As a contribution to scientific knowledge.

- 7.2 To define impacts of root diseases as a basis for:

- 7.2.1. Refining timber supply estimates.
- 7.2.2. Priorizing control opportunities.

- 7.3 To develop control methods, tactics and strategies as a basis for enhancing timber supplies.

- 7.4 To expedite application of research results at the operational level.

8. PROGRESS AND ACHIEVEMENTS

(a) Up to Prior Year 1

8.1 Epidemiology

Defined and published the epidemiology of the three major root rot fungi, Phellinus weirii, Armillaria, and Fomes annosus.

Elucidated taxonomy and pathogenicity of six Armillaria species in B.C.

Completed cultural studies and initiated pathogen viability studies for Verticicladiella wagneri.

Determined factors in colonization of stumps by F. annosus.

Defined relationship of extent of above-ground symptoms of P. weirii infection with extent of below-ground infection.

Completed preliminary investigation of epidemiology of P. tomentosus (Scientific authority, PRUF contract with UBC)

8.2 Impact

Defined and published stem growth impact variables in P. weirii-infected second-growth Douglas-fir. Determined and published stem growth impact in P. weirii infection centers in second-growth coastal Douglas-fir.

Developed and published ground-survey methodology for P. weirii in coastal stands.

Completed preliminary investigation of impact of P. tomentosus (scientific authority, PRUF contract with UBC).

Developed and published spread and impact model for P. weirii in coastal second-growth Douglas-fir stands.

Developed and published rating system for hazard trees in recreational sites in the West.

Developed and published database and analysis program for three plantations and ten naturally established stands comprising 20,000 trees.

8.3 Control

Developed and published control technology for P. weirii and Armillaria.

Defined and published control treatments for prevention of stump infection by F. annosus.

Established trials to test feasibility of Armillaria control.

Established trials for silvicultural control of P. weirii.

8.4 Technology Transfer

Completed 35 workshops on root disease management and control; 10 workshops on root disease survey methodology; 8 workshops on hazard tree management. Published guidelines for managing stands infected with P. weirii and Armillaria.

Demonstrated use of spread and prediction model at four forestry faculties and two professional training courses.

Provided survey methodology and data analysis for BCMF Vancouver Regional root disease survey.

Provided survey advice and data analysis and interpretation for all coastal districts.

(b) Current Year

8.1 Epidemiology

Investigation of factors affecting stump colonization by F. annosus was completed for coastal forest zone (13-073).

Isoelectric focussing was used to determine isozyme patterns for Armillaria isolates from the range of A. ostoyae in B.C. (13-135).

Stump roots were inoculated with P. weirii to determine susceptibility of buffer root systems to infection (13-072).

Limited viability of blackstain in lodgepole pine after felling was confirmed (13-379).

8.2 Impact

Plantation database was updated and longterm analyses carried out (13-071).

Developed and published aerial photo detection methodology for second-growth coastal Douglas-fir (13-310).

Initiated Armillaria spread and impact investigation in the Interior (13-135).

Initiated collaboration with BCMF on integrating Phellinus root rot model with Douglas-fir stand growth model (13-276).

Completed surveys for blackstain in lodgepole pine (13-379).

8.3 Control

Initiated cooperative field trials for modified spacing control of Phellinus root rot (13-072)

Maintained stump removal field trials (13-072).

8.4 Technology Transfer

Initiated arrangements for stump removal demonstration site with BCMF (13-072).

Served as scientific authority and provided crew training for ENVIRONMENT 2000 and Canada Works Contracts (13-072).

Provided decay culture identification (13-296).

9. BUDGET YEAR WORK PLAN

9.1 Epidemiology

Phellinus (13-072)

Update root infection viability study. Initiate resistance trials of selected D. fir crosses.

Initiate ecotypes relationship study (PDF proposal).

Armillaria (13-135)

Analyze isoelectric focussing data.

Fomes (13-073)

Determine factors affecting spread from spaced stumps to residual trees.

9.2 Impact

Phellinus

Complete aerial photo detection analysis on southern Vancouver Island. Initiate whole-stand digital analysis for root rot severity classification (13-310).

Complete integration of disease management model with BCMF D. fir stand growth model (13-276).

Extend impact studies to mature stands (cooperative study - MacBlo, BCMF).

Update plantation and natural stand disease database (13-072).

Armillaria

Continue and expand spread and impact study. Initiate aerial photo spread rate measurement study.

9.3 Control

Phellinus (13-072)

Initiate root residue sampling study. Update control plot records. Extend fertilizer application treatment. Complete thinning and modified spacing field trials (cooperative field trials).

Initiate tree improvement selected crosses infection trial.

Armillaria (13-135)

Maintain stump removal trial.

Fomes

Prepare materials for publication on control. Continue registration attempts for Zn sulphate.

9.4 Technology Transfer

Phellinus (13-072)

Produce field-crew guide.

Produce a manual on presentation of a root rot identification course. Select demonstration areas for mechanical and silvicultural control.

Maintain existing cooperative field trials (Pacific Forest Products, MacBlo, Duncan District BCMF) and extend to other cooperators.

Continue participation in Vancouver Region Root Disease methodology and analysis.

Act as scientific authority for PRUF contract for Pest Management and Decision Key (SFU).

Armillaria

Provide advice and services as required.

Fomes

Provide advice and services as required.

10. FIVE-YEAR WORK PLAN

Phellinus

Completion of aerial photo detection and appraisal for Phellinus.

Installation of control demonstration areas.

5 - 15 year evaluation of mechanical and silvicultural controls.

Develop ecological guidelines for Phellinus root rot management.

Complete support packages for workshop presentation.

Fomes

Complete work on factors affecting spread from colonized stumps to residual trees.

Prepare a publication summarizing epidemiology, damage etc. and giving guidelines for controlling the disease.

Terminate study.

Armillaria

Completion and application of spread and impact model for Armillaria integration and application of Phellinus disease management model with D. fir stand growth model.

Determine relative pathogenicity of Armillaria species occurring in B.C.

Establish control trials (inoculum reduction and species trials).

11. MAJOR COOPERATORS

B.C. Ministry of Forests
Crown Forests Ltd.
Canadian Forest Products Ltd.
Western Forest Products Ltd.
Horth Forestry Consultants
MacMillan Bloedel Ltd.

12. EVALUATION

13. LIST OF STUDIES

	<u>Study Title</u>	<u>P/Y</u>
-03	Disease sampling in Douglas-fir plantations; W. Bloomberg.	0.6
-04	<u>Phellinus weirii</u> root rot: epidemiology and control. W.J. Bloomberg	1.8
-05	<u>Fomes annosus</u> root and butt rot: epidemiology and control. D. Morrison	1.0
-06	<u>Armillaria</u> root disease: development and testing of stand management guidelines D. Morrison, W.J. Bloomberg	1.3
-69	Technology Transfer: root and stem diseases W.J. Bloomberg, D. Morrison, G. Reynolds	0.7
-07	Modelling root rot impact in managed coastal Douglas-fir stands W.J. Bloomberg.	1.0
-08	Mycological services; D. Morrison	0.4
-09	Remote Sensing root rot. J. Lee	0.4
-10	Host defense of tree diseases. G. Jensen	1.0
-02	Black stain root disease; biology and control. R. Hunt.	0
		<u>7.2</u>

TITLE

PC-53-03

Disease Sampling in Douglas-fir Plantations

Start: 1978
Compl: Cont.

STUDY LEADER- W.J. Bloomberg

PERSON YEARS

Expended to Date:	Prof. 2.5	Support 1.7	Total 4.2
Expended (84-85):	Prof. 0.0	Support 0.2	Total 0.2
Expended (85-86):	Prof. 0.1	Support 0.5	Total 0.6
Required to Compl:	Prof. cont	Support cont	Total cont

PROBLEM

Root rot losses in managed stands threaten their economic productivity. Long-term studies of development of root diseases in plantations are needed to provide forest managers with estimates of damage and advice on control.

OBJECTIVE

Assess the significance of root and stem diseases in Douglas-fir plantations and naturally regenerated second-growth stands by determining the increase in infection and mortality with time and the progressive changes in pattern, structure and composition of Douglas-fir plantations brought about through the activity of diseases.

RELATIONSHIP TO PROJECT OBJECTIVES

Contributes to the impact and control objectives of the project. Definition of the major diseases of Douglas-fir plantations and their rate of development over time will provide the forest manager with the information required in predicting future losses, allowing him to adjust control procedures as required.

STUDY PLAN SYNOPSIS

The study includes 10 permanent recording units established 20 to 40 years ago. A statistically sound survey method has been tested and published. A computerized data base has been implemented for 20,000 trees. Statistical and mapping options are included. Estimates of root rot spread and effect on stand structure will be derived from an analysis of the recording units. Survey methodology and loss prediction factors will be published in a form suitable for use by our clients.

GOALS FOR CURRENT YEAR

Update measurements in three plantations and one national stand. Terminate Bainbridge Lake plot.

PROGRESS AND ACHIEVEMENTS FOR 1984-85:

Development of Phellinus weirii in long-term plots in natural stands and plantations was recorded and analysed with a view to developing prediction factors for the build-up of the disease over time. The data are used by study PC13 - 276, root disease modelling.

Disease plots were updated and maintained.

Partial measurements made in plantations.

Database was updated and restructured. Analysis software was converted to VAX-computer. Analysis were made for spread rate over periods up to 50 years.

Publications

Bloomberg, W.J. 1983. Surveying for root disease losses in British Columbia. In Proc. 6th Internatl. Conf. on Root and Butt Rots of Forest Trees, IUFRO, Melbourne, Australia. pp. 359-371.

Program Manager	<u>Thomas E. Stora</u>	Date	<u>15 Apr. 1985</u>
Project Leader	<u>B. Bloomberg</u>	Date	<u>11 / 12 / 85</u>
Study Leader	<u>B. Bloomberg</u>	Date	<u>12 / 12 / 85</u>

TITLE

PC-53-04

Phellinus weirii root rot: epidemiology and control

Start: 1978

Compl: 1988

STUDY LEADER - W.J. Bloomberg

PERSON YEARS

Expended to Date:	Prof. 1.8	Support 2.1	Total 3.9
Expended (84-85):	Prof. 0.0	Support 0.7	Total 0.7
Expended (85-86):	Prof. 0.1	Support 0.7	Total 0.8*
Required to Compl:	Prof. 1.5	Support 0.3	Total 1.8

* Excludes possible 1.0 p/y PDF position.

PROBLEM

In B.C., Phellinus weirii root rot is estimated to cause an annual depletion in young timber stands of over two million cubic meters. Most commercial conifer species are susceptible to infection to varying degrees. A biological understanding of the fungus, required in research directed at control, is being gained through in vitro and in vivo studies. Silvicultural control procedures include site clearing and species manipulation; although costly and cumbersome, both of these practices are starting to receive acceptance. Alternative disease management options must be developed to provide flexibility in control prescriptions. Biological control procedures are being sought.

OBJECTIVES

Develop disease control strategies and methods using combinations of mechanical, chemical, silvicultural, biological, ecological and genetic approaches.

RELATIONSHIP TO PROJECT OBJECTIVES

Contributes to control objective of project. Provides symptomatology, management guidelines and control proposals for P. weirii root rot infected stands.

STUDY PLAN SYNOPSIS

A large body of knowledge exists on the biology of Phellinus weirii, the methodology for surveying damage and loss prediction and guidelines for controlling the disease. This knowledge should be, and is now being, drawn on to develop multi-option disease control strategies and methods.

An increased understanding of ecological relationships of root disease and natural resistance in the host population will expand the potential for control options.

GOALS FOR CURRENT YEAR

Extend mechanical, silvicultural and genetic control experiments by:

- a) Inoculating spaced buffer stump roots of various ages to determine period of susceptibility to colonisation by Phellinus.
- b) Establishing control trials in young Douglas-fir stands by clearing buffer strips around P. weirii centers.
- c) Complete modified spacing trials.
- d) Extend spaced stump root inoculation treatments to 2-3 year-old stumps. Examine previous inoculations.
- e) Outplant D. fir tree improvement crosses (BCMF) to test for P. weirii resistance.
- f) Develop sampling procedure for residual root assessment in cooperation with B.C. Forest Service testing of stump removal equipment.

PROGRESS AND ACHIEVEMENTS 1984-85

- a) The fumigant basamid was inconsistent in controlling P. weirii in stumps and living trees. All control plots and root disease spread plots were examined and records were updated.
- b) Spaced buffer stump roots were inoculated with P. weirii.
- c) Modified spacing field trials were conducted to test incorporation of silvicultural control of P. weirii with scheduled stand treatments.

Program Manager Thomas E. Storr Date 15 Apr 1985

Project Leader P. Blaney Date 4/12/85

Study Leader P. Blaney Date 4/12/85

TITLE

PC-53-05

Fomes annosus root and butt rot - epidemiology and control

Start: 1964

Compl: 1988

STUDY LEADER - D. Morrison

PERSON YEARS

Expended to Date:	Prof. 7.1	Support 8.7	Total 15.8
Expended (84-85):	Prof. 0.4	Support 0.8	Total 1.2
Expended (85-86):	Prof. 0.4	Support 0.6	Total 1.0
Required to Compl:	Prof. 6.0	Support 4.6	Total 10.6

PROBLEM

In coastal second growth stands, Fomes annosus causes mortality, butt rot and predisposes trees to windthrow. The fungus is also the most common colonizer of stem wounds on certain conifer species. Spread and intensification of the disease in second-growth stands is favored by intensive management operations.

OBJECTIVES

Establish guidelines for controlling root rot by minimizing infection of stumps and scars by Fomes annosus in intensively managed second-growth stands.

RELATIONSHIP TO PROJECT OBJECTIVES

Contributes to project objectives on epidemiology and control. Unless spore infection of stumps and scars is controlled in intensively managed second growth stands, part of the volume gained by management will be lost to butt rot and windthrow of trees with decayed root systems.

STUDY PLAN SYNOPSIS

To complete the study, a guideline for treatment of stumps in spaced stands and registration of zinc sulphate, the most effective stump treatment chemical, are needed. Stump species, stump diameter, season of spacing and ecological zone are being hazard-rated for stump infection. The effects of stump diameter and percentage surface area colonized on spread from colonized stumps to residual trees are being evaluated. We are working with BCMF Protection Branch to obtain registration of Zinc sulphate. On completion of the above, a publication summarizing epidemiology and control guidelines will be prepared.

GOALS FOR CURRENT YEAR

- a) Excavate colonized spacing stumps to determine factors affecting spread to residuals.
- b) Analyze results of stump sampling.
- c) Photograph decay, sporophore, spread etc. for publication on epidemiology and control.
- d) Continue efforts to register zinc sulphate.

PROGRESS AND ACHIEVEMENTS 1984-85

Stump sampling to determine the effects of tree species, stump diameter, seasons of spacing and ecological zone on stump colonization by *F. annosus* was completed for coastal forest zone. Excavation of colonized hemlock stumps was begun in a spaced stand near River Jordan. A paper was prepared on results of stump sampling and excavation in the Prince Rupert Forest Region.

Program Manager

James E. Jones

Date

15 April 85

Project Leader

B. L. Campbell

Date

4 / 12 / 85

Study Leader

D. Morrison

Date

4 / 12 / 85

TITLE

PC-53-06

Armillaria root disease: Epidemiology and development
and testing of stand management guidelines

Start: 1981
Compl: 1986

STUDY LEADER - D. Morrison

PERSON YEARS

Expended to Date:	Prof. 1.6	Support 3.1	Total 4.7
Expended (84-85):	Prof. 0.4	Support 0.8	Total 1.2
Expended (85-86):	Prof. 0.5	Support 0.8	Total 1.3
Required to Compl:	Prof. 1.2	Support 1.0	Total 2.2

PROBLEM

Confusion about the pathogenic importance of Armillaria has resulted in ambiguous attitudes towards its economic impacts. In B.C., there are six Armillaria species. Four of these occur on hardwoods and are weakly pathogenic. The other two are pathogenic on conifers; one has a very limited distribution whereas, A. ostoya causes mortality throughout the rotation in the Douglas-fir, interior cedar-hemlock and Engelmann spruce-subalpine fir zones in the Nelson and Kamloops Regions. Disease centers may occupy up to 30% of stand area. In contrast, mortality caused by A. ostoyae in coastal forests is usually confined to the first 20 years of the rotation and is usually not significant.

OBJECTIVES

- to understand the epidemiology of the principal Armillaria species in B.C.
- to field test disease management proposals and modify where necessary.
- to develop a model of spread and impact for A. ostoyae in interior forests.

RELATIONSHIP TO PROJECT OBJECTIVES

Contributes to project objectives on epidemiology, impact and control. The importance of A. ostoyae as a depletion factor in the Nelson and Kamloops regions requires development of sound guidelines for management of diseased stands. A model of the disease would be a useful management tool for predicting disease impact.

STUDY PLAN SYNOPSIS

Management proposals based on experiments and observations made between 1972-80 have been published. In cooperation with BCMF and Industry, field trials to test these proposals are being established. In addition, information for modelling on rate of spread in the tree, rate of centre

enlargement, relationship between above-ground symptoms and below-ground infection is required. It is important to know if variation in pathogenicity within A. ostoyae would account for the differences in amount of mortality between coast and interior.

GOALS FOR CURRENT YEAR

- a) Measure spread of A. ostoyae on the root system of 11 trees marked in 1977.
- b) maintain the control project at Phoenix (brush control).
- c) complete establishment of rate of spread plots at Sugar Lake.
- d) Analyse isoelectric focussing data to determine if there are subpopulations within A. ostoyae.
- e) measure impact of A. ostoyae on growth of Douglas-fir in two stands.
- f) establish rate of spread plots in a lodgepole pine plantation.

PROGRESS AND ACHIEVEMENTS 1984-85

In a 17 year-old Douglas-fir plantation near Sugar Lake, plots 50 m square were laid out on a two ha block and the coordinates of all dead and infected trees were determined. Increase in size of disease centers will be measured periodically.

In four disease centers marked in 1978, there has been a gradual increase in the percentage of root collar circumference showing resinosis.

Natural mortality, primarily from grass competition, was replaced at the Phoenix control study.

Using isoelectric focusing, the EST and PPO isozyme patterns were determined for about 100 isolates from the range of A. ostoyae in B.C. A paper was prepared on the species of Armillaria occurring in B.C.

A paper was published on "Incompatibility testing of Armillaria isolates in a wood substrate (Hood and Morrison Bimonthly Res. Notes 4: 8-9). A paper, based on Armillaria isoelectric focusing results, was published on Digital image analysis of isoelectric focusing patterns (Thomson et al. Electrophoresis 5: 55-56).

Program Manager

James E. Starn

Date

15 April 85

Project Leader

B. G. B. B. B. B.

Date

4/12/85

Study Leader

D. Morrison

Date

4/12/85

TITLE

PC-53-07

Modelling of root rot impact in managed
Coastal Douglas-fir stands

Start: 1975
Compl: 1985

STUDY LEADER - W.J. Bloomberg

PERSON YEARS

Expended to Date:	Prof. 3.8	Support 3.5	Total 7.3
Expended (84-85):	Prof. 0.5	Support 0.5	Total 1.0
Expended (85-86):	Prof. 0.5	Support 0.5	Total 1.0
Required to Compl:	Prof. 0.3	Support 0.5	Total 0.8

PROBLEM

Root rot is the most important biological cause of loss in second-growth coastal Douglas-fir stands. Growth models of these stands require a root rot submodel in order to produce realistic root yield predictions. In addition, management guidelines for estimation of root rot and prediction of effects of silvicultural treatments can be effectively developed by simulation techniques.

OBJECTIVE

- a) Develop computer models for root rot;
- b) Integrate root rot models as a submodel of a stand growth model;
- c) Develop management guidelines for control of root rot based on results from models.

RELATIONSHIP TO PROJECT OBJECTIVES

This study contributes to the epidemiology, impact, control and technology objectives of the project.

STUDY PLAN SYNOPSIS

Computer models to be developed using in-house computer. Models should simulate spread of Phellinus weirii root rot in second-growth Douglas-fir stands and allow testing of control treatments. Data for mathematical relationships in model to be obtained from information published by PFRC and elsewhere, and from field samples. Model to be tested by comparison of estimates of disease spread and severity with as many field situations as available. Model to be interfaced with BCMF Douglas-fir growth model.

With one year remaining in the study, the status of the three objectives is:

- a) Stand model completed, single-tree model 90% complete.

- b) Work initiated in collaboration with Dr. K.J. Mitchell, BCMF.
- c) Implemented for stand model; not yet implemented for single-tree model.

GOALS FOR CURRENT YEAR

Develop initial version of root rot submodel in the Douglas-fir stand growth model.

PROGRESS AND ACHIEVEMENTS FOR 1984-85

- a) Initiated work on interfacing Phellinus root rot model with Douglas-fir stand growth model.
- b) Published report on estimation of growth reduction caused by Phellinus root rot in second-growth Douglas-fir stands.
- c) Submitted for publication report on relationships of root and stem growth in healthy and Phellinus-infected Douglas fir.

PUBLICATIONS

Bloomberg, W.J. 1984. Computer models as tools in forest disease management. In Rept. of the 17th Meet. North. Am. For. Comm., Study Group on for. insects and dis., Las Cruces, NM. pp. 1-21.

Bloomberg, W.J. 1984. Modelling applied to the analysis of crop-pest management interactions; a forest pathology example. Proc. Can. Entomol. Soc. Ann. Mtg. St. Andrews, N.B. In press.

Bloomberg, W.J. and G. Reynolds. 1985. Growth loss and mortality in laminated root rot infection centers in second growth Douglas-fir on Vancouver Island. For. Sci. In press.

Bloomberg, W.J. and A.A. Hall. 1985. Relationship of root system size, structure and distribution to stem growth in healthy and Phellinus weirii-infected Douglas fir. For. Sci. Submitted.

Program Manager	<u>Thomas E. Steiner</u>	Date	<u>15 April 85</u>
Project Leader	<u>W. J. Bloomberg</u>	Date	<u>4/12/85</u>
Study Leader	<u>W. J. Bloomberg</u>	Date	<u>4/12/85</u>

TITLE

PC-53-08

Mycological Services

Start: 1978
Compl: 1988

STUDY LEADER - D. Morrison

PERSON YEARS

Expended to Date:	Prof. 0.0	Support 2.3	Total 2.3
Expended (84-85):	Prof. 0.0	Support 0.2	Total 0.2
Expended (85-86):	Prof. 0.0	Support 0.4	Total 0.4
Required to Compl:	Prof. 0.0	Support cont.	Total cont.

PROBLEM

As well as a considerable in-house demand for identification of cultures of wood decay fungi there is also a stated need from the B.C. Ministry of Forests and other agencies. To aid in the identification of cultures and to provide a readily available source of experimental material, it is essential that a collection of cultures of wood decay fungi be maintained. The general pathology laboratory is used not only by all pathology projects but also by at least three other disciplines; readily available supplies of chemicals, glassware and other culture medium ingredients are required by these users.

OBJECTIVES

- a) Provide mycological services to Government agencies (Provincial and Federal and PFRC projects);
- b) Maintain a culture collection of wood decay fungi for reference and experimental purposes;
- c) Maintain stores of glassware, chemicals and culture medium ingredients for use by pathology projects and other users and ensure that all lab equipment is maintained.

RELATIONSHIP TO PROJECT OBJECTIVES

A well equipped lab and a culture collection are essential to studies involving experimental use of fungi. Similarly, the identity of fungi causing decay, invading stumps or killing trees must be determined if an appropriate control procedure is to be recommended. Our clients (the Forest Service and Industry, primarily) also depend on the fungus identification service provided by this study.

STUDY PLAN SYNOPSIS

The above objectives will be achieved annually.

GOALS FOR CURRENT YEAR

- a) identify cultures of wood decay fungi for B.C. Ministry of Forests pathologists at PFRC, and other clients.
- b) add to the culture collection as new isolates are received.
- c) maintain the pathology lab in a clean and orderly condition, prepare media for use by staff and B.C. Ministry of Forests and ensure that equipment is in good working order.
- d) provide other mycological services, as requested.

PROGRESS AND ACHIEVEMENTS FOR 1984-85:

About 140 samples were received for culturing and identification, of which 75% were Basidiomycetes. Samples were received from FIDS, the public and PC13-073 + 135. Assistance with identification of cultures was also provided to a U.B.C. forestry student.

Program Manager

Thomas E. Stenroos

Date

15 Apr 1985

Project Leader

B. G. G. G. G.

Date

4/12/85

Study Leader

D. Morrison

Date

4/12/85

TITLE

PC-53-09

Use of remote sensing techniques for the detection,
survey and damage appraisal of root diseases

Start: 1978
Compl: 1990

STUDY LEADER - Y.J. Lee and W.J. Bloomberg

PERSON YEARS

Expended to Date:	Prof. 2.3	Support 0.5	Total 2.8
Expended (84-85):	Prof. 0.2	Support 0.1	Total 0.3
Expended (85-86):	Prof. 0.3	Support 0.1	Total 0.4
Required to Compl:	Prof. 1.2	Support 0.4	Total 1.6

PROBLEM

The current method of using ground survey technology to rate stands for root disease impact is both costly and time consuming. Determination of spread rates by permanent sample plots requires remeasurement over many years. If root disease damage could be identified and spread rates determined by the use of remote sensing techniques, efficiency would be greatly improved. Digital analysis of microdensitometric data using an Image Analysis System is a potentially useful tool for locating root disease centres on aerial photos. Research is needed to determine the usefulness of these techniques.

OBJECTIVES

To determine the accuracy with which root disease centers can be identified and rates of spread calculated using visual interpretation techniques.

To determine if digital analysis of microdensitometric data using an Image Analysis System is effective for distinguishing root disease centres and the rate of spread, and for rating stands for disease severity.

RELATIONSHIP TO PROJECT OBJECTIVES

Contributes to disease impact objectives of the project.

STUDY PLAN SYNOPSIS

Color, color infrared and black and white aerial photographs of Douglas-fir stands of various ages will be scanned for root disease damage; results will be ground truthed. The photos will be digitized using CCRS microdensitometry. The digital data will be analysed using an Image Analysis System. Correlations between digital analysis results and ground survey estimates will be tested.

GOALS FOR CURRENT YEAR

Analyse Greater Victoria Watershed root rot data and prepare report.

Conduct image analysis on selected photo samples.

Select black and white periodic aerial photographs within the last 50-year for one or several stands, to be digitized using CCRS microdensitometer. These digital data will be used to study the rate of root disease spread with remote sensing image analysis techniques.

PROGRESS AND ACHIEVEMENTS FOR 1984-85

Wallis, G.W. and Y.J. Lee. 1984. Detection of root disease in coastal Douglas-fir stands using large scale, 70-mm aerial photography. Canadian Journal of Forest Research Vol. 14: 523-527.

Wallis, G.W. and Y.J. Lee. 1984. Detection of Phellinus weirii using large scale 70 mm aerial photography. Proceedings of the 6th IUFRO, Melbourne, Australia August 25-30, 1983: 372-376.

Field data for mapping and determination of volume losses were completed.

Digitization of selected photo samples were completed.

Program Manager

Thomas E. Starnes

Date 10 Apr 1985

Project Leader

B. C. C. C. C.

Date 4/12/85

Study Leader

Y. J. Lee

Date April 12, 1985

TITLE

PC-53-69

Technology Transfer: root disease of conifers

Start: 1978

Compl: cont

STUDY LEADER - W.J. Bloomberg, D.J. Morrison, G. Reynolds

PERSON YEARS

Expended to Date:	Prof. 5.0	Support 2.9	Total 7.9
Expended (84-85):	Prof. 0.6	Support 0.3	Total 0.9
Expended (85-86):	Prof. 0.3	Support 0.4	Total 0.7
Required to Compl:	Prof. cont.	Support cont.	Total cont.

PROBLEM

Root disease losses jeopardize timber supply planning and cause disruption of intensive silvicultural plans. Effective management of root disease depends on a practical grasp, by field foresters, of disease recognition, epidemiology, damage appraisal and control procedures. Currently, the knowledge level on these topics is unevenly distributed in the field forester population.

Evaluation of applied research in root disease management procedures depends on feedback from forest managers through cooperative field trials under operational conditions. Because of limited project resources, root disease researchers must seek out opportunities for cooperation with BCMF and industrial foresters on labor-intensive trials.

OBJECTIVES

To provide an array of technology transfer options designed to ensure a full practical understanding of root rot taxonomy, epidemiology, damage appraisal and control procedures at the field forester level by:

- 1) Workshops
- 2) Information Reports
- 3) Audio-visual presentations
- 4) Field demonstration areas
- 5) Cooperative field trials
- 6) Consultation

RELATIONSHIP TO PROJECT OBJECTIVES

Contributes to control and technology transfer objectives of project.

Field Demonstration Areas

Initiated efforts to utilize plantation plots and overall stumping site (Hwy 18 near Duncan) as a demonstration area for forestry students and visiting forestry personnel.

Cooperative Field Trials

In cooperation with Pacific Forest Products, established root rot monitoring plots within spaced stands to determine effect on spread of Phellinus.

In cooperation with BCMF, established plantation plots within stumping trial site (Hwy 18 Duncan) to assess effectiveness of treatment.

In cooperation with BCMF research ranch Victoria and Mesachie Lk., potted selected tree improvement Douglas-fir crosses and arranged for site preparation for outplanting in 1985 (N. Arm. Lk. Cowichan). Trees to be inoculated with Phellinus 1987-88.

Information Report

Compiled summaries of all studies on root diseases to date and distributed to BCMF and forest industry representatives as basis for discussion and review of root disease research program.

Scientific Authority

Acted as survey methods and data analysis consultant to BCMF Vancouver Regional root disease survey.

Acted as consultant to BCMF Powell River District root rot impact plot establishment.

Recommendations to:

Municipality of North Cowichan, re. the establishment of mensurational plots relative to the distribution of root disease centers.

Program Manager

Thomas E. Starnes

Date

15 April 85

Project Leader

Blaumberg

Date

4/12/85

Study Leader

D. Morrison

Date

4/12/85

Healy

APPENDIX 3



United States
Department of
Agriculture

Forest
Service

Pacific
Northwest
Region

319 S.W. Pine
P.O. Box 3623
Portland, OR 97208

3400

Reply to:

Date: MAR 25 1986

Dr. John Muir
British Columbia Forest Service
1450 Government Street
Victoria, BC CANADA V8W 3E7

Dear John:

For your information, we are sending a list of research needs identified by our pathologists in Forest Pest Management. This list was presented to USDA Forest Service Pacific Northwest Region (PNW) research personnel during a meeting held March 11 at Corvallis, Oregon. This is an annual meeting at which research directions and needs are discussed among research personnel and those with responsibilities of working directly with land managers. This year's meeting was attended by PNW research pathologists and mycologists, pathologists for the States of Oregon and Washington, Oregon State University, as well as Forest Pest Management.

Sincerely,

James S. Hadfield

JAMES S. HADFIELD
Acting Director of Forest Pest Management

Enclosure

RECEIVED
APR 1 1986

PROTECTION BR.
B.C.F.S. VICTORIA



FOREST DISEASE INFORMATION NEEDS IDENTIFIED BY
FOREST PEST MANAGEMENT, PACIFIC NORTHWEST REGION

ROOT DISEASES

Highest Priority

Develop computer models that will predict amount of damage to be experienced in stands affected by the major root diseases. Ultimately, we would like to have programs that could project loss at any point in a stand's future based on knowledge of current root disease occurrence (amount and distribution), stand and site character, and proposed management regime. Root diseases by order of priority are: (1) laminated root rot, (2) Armillaria root disease of East Side conifers, (3) black stain root disease, (4) annosus root disease of East Side true firs, (5) Port-Orford-cedar root rot, and (6) complexes involving several root pathogens.

High Priority

We realize that many of these projects are probably part of the above highest priority item.

Determine site and environmental factors that influence incidence and severity of the major root diseases in Pacific Northwest forests. Examine such factors as soil type and character, site disturbance, aspect, percent slope, slope position, slope shape, ecoclass, macro-and micro-climate, etc. Employ a systems approach.

Develop remote sensing techniques for detecting and assessing root diseases. Concentrate on improving aerial photography and interpretation techniques.

Continue to investigate extent of infection in root systems beyond visible crown symptoms. For each of the major root diseases, we need to know how far beyond the visually detectable margin of an infection center the zone of infected roots extends. Correlate with studies on site and environmental conditions.

Examine mechanisms of host resistance to the major root diseases. Are there differences within susceptible host species in amount of resistance, and if some resistance exists, can this be used in a pest management program? Of special interest is resistance of Douglas-fir to Phellinus weirii.

Determine where western hemlock, noble fir, Engelmann spruce, and sugar pine fit in the laminated root rot susceptibility scheme.

Investigate how new P. weirii infection centers develop.

Develop accurate economic analyses of root disease control programs. Determine economic and physical effects in second and third generation stands on untreated, infected sites.

Investigate the traditionally held belief that West Side Douglas-fir becomes resistant to Armillaria root disease at age 30.

Investigate the possibility of developing practical biological and chemical controls for Armillaria root disease.

Investigate the possibility that in West Side Douglas-fir stands, older trees develop resistance to black stain root disease.

Investigate the possibility of developing practical biological and chemical controls for black stain root disease.

Investigate the possibility of biological control of F. annosus on East Side true firs.

Investigate effects of inoculum source size and age on infectivity of F. annosus on East Side true firs.

Investigate early logged areas which have reverted to alder where the original stand had Douglas-fir infected with Phellinus weirii. Check on the time interval viability of P. weirii in the soil so that we can determine when is it safe to (re)grow Douglas-fir.

Dwarf Mistletoes

Highest Priority

The effects of dwarf mistletoe infestations upon periodic volume increment and cumulative volume of managed Douglas-fir and western larch stands need to be quantified. At the present time, we are unable to realistically predict these effects and this is hindering management on many thousands of acres.

High Priority

The rate of dwarf mistletoe intensification in trees and stands needs to be determined for the following Pacific Northwest tree species: Douglas-fir, larch, ponderosa pine, lodgepole pine, and true fir. We need to know how big trees must be before they become infected, how old, and how far dwarf mistletoe seeds spread from overhead infection sources.

Information is needed on the dwarf mistletoe-canker fungi complex that is affecting true fir stands in the Cascades and south-central Oregon. Factors favoring infection by the canker fungi need to be elucidated. Pathogenicity of fungi isolated from cankers needs to be tested. Forest Pest Management is measuring effects on growth. The fate of dwarf mistletoe-infected true fir stands needs to be predictable.

Medium Priority

Elucidate conditions necessary for establishment and effectiveness of biological controls (especially fungi) of dwarf mistletoes. Can we propagate the fungi and inoculate them?

Determine if the severity of dwarf mistletoe damage varies with ecoclasses of the following tree species: Douglas-fir, ponderosa pine, lodgepole pine, larch, and true firs.

Regeneration Diseases

High Priority

Development of disease risk-rating systems to determine if treatment is needed to prevent or reduce losses in Pacific Northwest nurseries.

This could involve measurement of pathogen populations, pathogenicity of isolates, determination of susceptible host species, measurement of host vigor, environmental conditions, and cultural practices and the relationship of the above items to disease severity.

Diseases: Damping-off
 Fusarium hypocotyl rot
 Fusarium root rot
 Douglas-fir canker diseases
 ("top blight")

Manipulation of soil microflora and/or chemistry to reduce populations of pathogenic organisms in nursery soil or to prevent rapid reinvasion of pathogens after treatments (creation of "disease suppressive" soil).

Populations of pathogenic soil microorganisms may be altered by introduction of other organisms, by soil management, or by the combination of the above. Research should be directed towards discovery and isolation of antagonists, study of their ecological relationships, and development of procedures for culture and field application.

Continue development of inoculum preparation and inoculation techniques for nurseries using site-specific, host-specific mycorrhizae.

Field performance of mycorrhizal-inoculated stock; measurement of growth and survival of outplanted seedlings inoculated in the nursery; measurement of development, survival, or replacement of nursery-inoculated mycorrhizae by other species in the field. Determine type of sites where specific mycorrhizae inoculation is needed.

Identification of fungi associated with flowers, pollen, seed, and cones of important Pacific Northwest trees. Pathogenicity of isolated fungi; inoculum origin and spread; conditions conducive to pathogen survival and development on seeds.

Determine role of seed and cone insects as vectors of pathogens (fungal, bacterial, viral).

Medium Priority

Identification of plant parasitic nematodes in Pacific Northwest nurseries; determine impact on seedling production.

Role of Pythium spp. in causing or contributing to seedling disease or poor vigor. Identification and pathogenicity of Pythium spp. isolated from nursery soil and seedling roots.

Biological control of Botrytis grey mold in PNW nurseries and greenhouses. Identify potential biological control agents, mode of action, inoculum production and field application.

Develop an illustrated guide for diagnosis of nutrient deficiencies and toxicities in seedlings.

Develop an illustrated guide for diagnosis of air pollution damage in seedlings.

Field performance of storage-molded stock. Identify mold organisms, determine conditions necessary for infection in storage, develop rating system for field survival based on such factors as percent foliage molded, length of time in storage, storage temperature, host species, mold species.

Role of drought stress in causing or increasing seedling disease. This could be expanded to include the effects of any type of environmental stress on disease development. Diseases which appear to be affected by drought stress are root rots and stem cankers.

Stem Decays

Highest Priority

Determine the potential for prevention of decay in living trees through biological control, biochemical manipulation, or genetic resistance. Research could take a similar direction as that taken in eastern hardwoods and European forests. Decay prevention is of great concern in Oregon and Washington, both in the commercial forest and in developed recreational areas.

High Priority

Do common decay-causing fungi such as F. annosus, F. pini, P. schweinitzii, and E. tinctorium enter through wounds, are they activated by wounding, or both? The problem has been addressed in Canada for E. tinctorium on western hemlock, but is the process similar for other tree species and other decay fungi?

Determine the relationship between extent of decay in living trees and the probability of such trees failing. There are no data available to allow forest recreation site managers to determine accurately the forces needed to cause decayed trees to break.

What is the potential of prescribed burning to predispose trees to decay? It is believed that many decay organisms enter living trees through wounds created by fire. Prescribed burning as a management tool has the potential for causing wounds in residual trees, thereby creating suitable entrance courts for decay fungi.

Medium Priority

Develop economical methods for logging that result in minimal wounding of residual trees. Methods have been developed in California to reduce logging damage to residual trees. Are such methods applicable in forests of Oregon and Washington?

Determine if P. schweinitzii is carried over from old growth to second-growth Douglas-fir on infected sites. P. schweinitzii has been shown to cause damage in second-growth trees in Idaho.

What roles do insects play in decay of trees; i.e., vectors, increasing infection courts for decay fungi and/or activate dormant decay fungi already present. Severe top defoliation has been shown to kill tree tops leading to decay of the living stem below the dead top.

Conversely, what is the role of decay in predisposing trees to insect attacks. Many species of bark beetles are attracted to trees weakened by other causes. Trees with substantial decay volumes may be weakened to the point of being attractive to bark beetles.

What are the effects in incipient decay by Fomes annosus on wood quality and physical, chemical properties in western hemlock? Does incipient decay cause a loss or degrade that can be quantitatively measured?

What stand and site characteristics can be used to predict hazard from decay caused by E. tinctorium in young-growth true fir? Research needs to be continued in this area if we are to be better able to hazard rate young stands.

Determine the infection process of F. pini in young-growth Douglas-fir stands. Is F. pini a problem in young-growth stands?

Develop methods for enhancing slash decay. Slash disposal is a major concern in site preparation. Methods developed in eastern Washington may need further research to determine their feasibility in various timber types in Oregon and Washington.

Determine rates of colonization and decay following injury or death due to fire, insects, weather, or other causes. Although much has been published in this area, more detailed information is needed for different stand conditions.

Research the important decays of Pacific Northwest hardwood species. As we move into utilization of hardwoods as a timber resource in this Region, more information is needed on the important decay-causing organisms causing damage in commercially valuable hardwoods.

Cankers-Stem Diseases

Medium Priority

Determine what relationships, if any, exist between severity of damage and specific plant communities with important tree rust fungi. Specific pathogens should include: white pine blister rust (Cronartium ribicola), western gall rust (Endocronartium harknessii), stalactiform rust (Peridermium stalactiforme), and comandra blister rust (Cronartium commandrae).

Determine what effect white pine blister rust (C. ribicola) has in predisposing white pine (Pinus monticola) to the mountain pine beetle (Dendroctonus ponderosae).

What potential biological controls are available for white pine blister rust (C. ribicola)? What possible role does Fusarium spp. play in this scheme?

Determine the relationship between extent of stem area affected by cankers and the probability of such trees failing. This information is needed for recreation site management decisions.

Determine if 5-needle pine mortality caused by Cronartium ribicola is influenced by tree size classes in Oregon and Washington. Researchers in Idaho have discovered lethal infections occur close to the stems of small trees. In British Columbia, the majority of lethal infections occurs close to the ground.

Forest Pathology Research Needs - East Side

The Pathology Group in R-6 has developed the attached list of needed forest pathology research for eastern Oregon and Washington. Three priorities have been designated.

**Highest
*High
Medium

In our estimation, the highest priority for research is on Douglas-fir dwarf mistletoe because the problem is so widespread, has drastic effects on the productivity of infested sites, and has a high potential for successful management. The prospects for implementation of research results are probably excellent.

Douglas-fir dwarf mistletoe -

The effects of dwarf mistletoe on growth and mortality of managed Douglas-firs are largely unknown. About 42 percent of the East Side Douglas-fir type is infested with dwarf mistletoe. Research is needed to answer the following questions:

- ** 1. How much growth retardation and quality reduction is associated with different increments of crown and stand infection? Data should be suitable for growth simulators such as Prognosis.
- ** 2. How rapidly do crowns of trees with visible and latent infections decline when they are released from competition?
- ** 3. How rapidly does dwarf mistletoe intensify within tree crowns?
- ** 4. How rapidly does dwarf mistletoe spread through stands?
- ** 5. How quickly does dwarf mistletoe build up in susceptible understories?
- 6. Do dwarf mistletoe-infected trees serve to maintain endemic populations of western budworm and/or Douglas-fir tussock moth by producing food and habitat essential for their survival?
- 7. Do dwarf mistletoe-infected trees die sooner from defoliation by western budworm and tussock moth than mistletoe-free trees?

8. Do dwarf mistletoe-infected trees and stands maintain endemic populations of bark beetles?

Western larch dwarf mistletoe -

Forty-seven percent of the western larch type in Washington and Oregon is infested by dwarf mistletoe. A newly emerging perception is that infected western larch can probably be grown to merchantable sizes if overstories are removed and trees are properly spaced to reduce competition. This perception is not based on data. The questions are:

1. How much growth retardation and quality reduction is associated with different increments of crown and stand infection? Data should be in a form suitable for use in growth simulators such as Prognosis.
2. How rapidly does dwarf mistletoe intensify within tree crowns and stands from which the overstory has been removed and the trees properly spaced?

Root Diseases -

Root diseases have always been serious problems in East Side forests. Evidence indicates the root disease problem is becoming more serious as a direct result of forests management activities.

1. Determine site and environmental factors that influence the incidence and severity of root diseases, especially Fomes annosus, in true firs in East Side forests. Examine such factors as soil type and character, site disturbance, aspect, percent slope, slope position, slope shape, ecoclass, micro- and micro-climate, etc. The objective would be to develop a hazard prediction technique.
2. Elucidate differences in host species susceptibility to Armillaria root rot from area to area on the East Side. Why, for example, is Douglas-fir very susceptible around Colville, Washington, and relatively tolerant around Glenwood, Washington, while ponderosa pine exhibits the opposite trend? Is this due to difference in fungus strain, host vigor, host strain, environmental conditions, or what?
3. Do root disease-infected trees serve to maintain endemic populations of western budworm and/or Douglas-fir tussock moth?
4. Do root-diseased trees die sooner from defoliation by western budworm and tussock moth than disease-free trees? Does A. ostoyae attack trees (Abies, Douglas-fir) predisposed by defoliators?
5. Investigate the possibility of biological control of Fomes Annosus in true fir stands.
6. Determine where Engelmann spruce fits in the laminated root rot susceptibility scheme.

7. Determine the relationship between stump size and F. annosus colonization in grand fir.

Regeneration -

1. Identify diseases adversely affecting natural regeneration in the first 2 years of development. We are especially interested in the first growing season.

Stem Decays -

Stem decays still consume enormous volumes of wood each year. These losses will continue to occur in spite of lowered rotation ages.

1. Determine the potential for prevention of decay in living trees through biological control, biochemical manipulation, or genetic resistance. Research could take a similar direction as that taken in eastern hardwoods and European forests.
2. What is the potential of prescribed burning to predispose trees to stem and root decay?
3. Determine rates of colonization and decay (pictorially) following injury or death due to fire, insects, weather, and other causes.

The Boise Field Office of R-4 Forest Pest Management was asked to provide suggestions on needed forest pathology research. The area they serve is similar in forest species to that covered by PNW Station in eastern Oregon.

Region 4 research needs in descending order of priority are:

1. Quantify the losses caused by dwarf mistletoes in Intermountain ponderosa pine and Douglas-fir. The data should be suitable for use in growth simulations such as Prognosis. Emphasis should be placed on managed stands.
2. Evaluate site/stand characteristics and their influence on Fomes annosus in Intermountain ponderosa pine and subalpine fir stands.
3. Identify nonmortality-causing agents involved in root/butt decay of Douglas-fir.
4. Evaluate the relationships of stem/root decay to tree/stand stress factors including defoliators, needle diseases, and abiotic factors.

Primary emphasis
Secondary
Third

Douglas-fir and defoliators
True firs and defoliators
Ponderosa pine

5. Clarify the impact and site associations of major pine stem rusts; western gall rust, stalactiforme rust.