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CONTROL OF *PORIA WEIRII* STUDY ESTABLISHMENT AND PRELIMINARY EVALUATIONS

by

L. C. Weir and A. L. S. Johnson

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Introduction

An important cause of loss of immature timber in British Columbia and the northwestern United States is the root-rotting fungus, *Poria weirii* Murr. Recent estimates have placed the annual loss in British Columbia at nearly 37 million cubic feet. Childs and Shea (1967) give an annual loss figure of 32 million cubic feet for the Pacific Northwest. Studies by Childs (1949, 1951) and Wallis and Reynolds (1965) have shown that stand infection arises almost exclusively through vegetative growth of the fungus via root contacts and grafts between healthy and infected roots. A prime source of infection lies in infected stumps and roots left after logging which will ultimately re-establish infection foci in the new forest. This subterranean infection and spread makes assessment of the degree of stand infection difficult and renders direct control, i.e., application of control materials to infected areas, impracticable economically and physically.

Estimates of the duration of viability of *P. weirii* in stumps and roots indicate that infected areas would be unsuitable for the growth of susceptible species for more than 50 years. Susceptible species include all commercially important conifers in British Columbia, although the degree of susceptibility varies.

Infected areas might continue to produce commercially acceptable forests if inoculum removal could be achieved. This report deals with the initiation and progress of an experiment since 1968, designed to study the effects of inoculum removal by scarification.

Materials and Methods

An area containing Poria infection centers was selected near Salmon Arm, B.C. A block 9 chains square (8.1 acres) was permanently marked and divided into a central study area 8 chains square (6.4 acres) and a surrounding strip 0.5 chains wide. All trees within the block were tallied with respect to species, diameter, condition (alive or dead), and position in the block to the nearest 0.5 feet. The study area was divided into two plots, each 4 chains wide and 8 chains long, to provide for treatment and control areas. All trees on the entire 8.1 acres were felled; the control area being logged conventionally, and the treatment area whole-tree logged, i.e., trees pushed over and yarded to the landing with attached roots.

Following completion of tree removal, the area designated for treatment was scarified to a depth of 18 inches by a D-8 caterpillar tractor equipped with a toothed land-clearing blade. The surrounding strip was also scarified to lessen the chance of infection entering the plot from outside the boundaries and also to provide study areas to evaluate the physical and biological effects of scarification.

The treatment and control plots were divided into 32 plots, each 1 chain square. These subplots were planted to pure species and mixed-species with three replications of each species and combination of species according to a random design (Fig. 1). Seedling of three coniferous species, Douglas fir (*Pseudotsuga menziesii* (Mirb.) Franco), lodgepole pine (*Pinus contorta* Dougl. var. *latifolia* Engelm) and western red cedar (*Thuja plicata* Donn), were incorporated in the design as well as seedlings of one deciduous species, birch (Betula papyrifera Marsh var. commutata (Regel) Fern). The number of species and their combinations as used required only 30 subplots in each of the treatment and control areas; the remaining two subplots in each area were planted to spruce (Picea engelmannii Parry) and larch (Larix occidentalis Nutt). All planting material was supplied by the British Columbia Forest Service except seedlings of cedar and birch. Lack of nursery stock of these species forced the use of wildings from the immediate vicinity of the study area.

To determine the effect of scarification on residual root sizes and their distribution, two pits were excavated near locations of Poria-infected trees. One pit was in the scarified surrounding strip and the other in the control area. Excavations were made to a depth of two feet in one-foot levels. A total of 287 cubic feet of soil from the pits was screened with all roots, other than those of shrubs and weeds collected and transported to the laboratory for examination. The examination included the recording of fungi present, the length of each root to the nearest 0.5 cm and an average diameter measured in millimeters and grouped into 4 diameter classes. The results, including approximate volumes of each root, were reduced to values per cubic foot of soil. Roots were further separated into 4 groups related to the fungi present: (1) those with Poria weirii, (2) those with Armillaria mellea (Vahl ex Fr.) Quel., (3) those with other fungi, including some like Merulius himantioides Fr. (Serpula himantioides (Fr.) Bond.), and (4) roots having no apparent infection.

Results

The tally of standing coniferous trees (Table I) presents a picture of the mortality that had occurred in the areas from Poria root rot, especially in the larger diameters. When the stumps of trees whose death had occurred prior to the commencement of this study, 103 in number, are added to the total of dead trees, the 8.1 acres had a 20% mortality in coniferous trees. Examination of tree stumps cut immediately before treatment showed that between 60% and 70% of the conifers on the area were infected.

An assessment of seedling mortality through mis-planting and winter-kill was made in July, 1969. The results (Table II) indicated a level of survival in Douglas fir in the scarified area that was somewhat higher than is apparently normal in the Kamloops Forest District following fall planting of the species. The per cent survival of the species in the untreated plots is much closer to the expected survival of Douglas fir. The wilding cedar mortality is very high and it is expected that some difficulty will be experienced in establishing the species as a component in the experiment since the protective overstory has been removed and the entire area more exposed than is normal for cedar growth. Yet, even with this species, survival is better in the scarified area. The low mortality of the birch wildings, where evaluated, is gratifying in view of the reaction of the wilding cedar. Seedling mortality in the untreated area is most probably related to the inexperience of planting personnel and to competition from plants and shrubs already present.

A discrepancy between the number of seedlings of each species planted can be seen in the table. This results partly from actions of the planting personnel and partly from the fact that at 5 x 5 spacing in the mixed-species plots, one species is planted in seven rows of 13 seedlings and the other in six rows. The choice of species to occupy the greater number of rows was arbitrary and not always consistent. This discrepancy will be repaired when the seedling mortality is replaced, the principal aim in planting being to have a full complement of healthy seedlings in each of the treatment and control areas.

The results of the pit excavations and root examinations (Tables III and IV) show that, in total, a marked reduction in the root volume in one cubic foot of soil was achieved by scarification. In the upper level (Table III), only Group 4 has an increase in volume and it is not excessive. In all groups there is a distinct increase in root number and length, but calculations show that in Groups 1 and 2, which contain the damaging root pathogens, over 95% of the roots are in the smallest diameter class and 1.00 cm or less in diameter.

Larger roots have apparently been removed from the lower level (Table IV) almost completely, which suggests that portions of these roots form part of the root complement in the upper level either through actual inverting of position during scarification or through deposition during the process of whole-tree yarding.

Discussion

The data from the experiment to control Poria root rot by scarification are of economic interest and importance. While most of the information is of a preliminary nature, some basic facts emerge.

Scarification completely alters the distribution of roots in the first two feet of soil. The whole-tree method of logging contributes to this distribution. What is of extreme importance is the small size of the majority of the roots left in the upper level, and the virtually complete removal of large roots from the lower level. The practice of whole-tree logging should be encouraged where it is feasible because of the contribution such a method would make to site preparation. The importance of root size rests on the possibility of rapid disintegration of small roots from the action of soil-borne micro-flora and wood-rotting organisms that occur as normal inhabitants of forest soils.

The calculation of data on a basis of one cubic foot of soil provides an adequate vehicle for demonstrating differences in root measurements between treated and untreated areas. It does not, however, give an accurate picture of the actual situation, in that it is obvious that there are roots larger than 1.00 cm in diameter still present in the upper level of soil that may be capable of causing infection through root contact. At the present time no data are available that relate specifically to the minimum size of inoculum of Poria weirii from which infection might arise. Garrett (1956) contends that volume of inoculum is a major factor in the successful spread of root-inhabiting fungi and quotes the work of Alston on Fomes lignosus (Klotzsch) Bres. to illustrate his contention. While direct comparisons between P. weirii and F. lignosus, with regard to inoculum potential cannot be made, the data on the latter fungus could provide an indication of possible results from scarification. Calculations based on an assumed similarity in potential between the two fungi, and applied to the actual number of roots in the scarified sample, show that there is only one root with a potential of infecting 100% of the contacts made. There are no roots with an infection capability of 50% and 21 roots with potentials less than 22%. In the untreated plot, for infection potentials of 100%, 50% and less than 22%, the corresponding numbers of roots are 15, 5 and 51, respectively.

These values are conjectural but serve to indicate the value of scarification as well as a possibility latent in the residual roots. Further testing and study will show if, in fact, the smaller diameter roots retain a potential for infection under the effect of competing microorganisms.

With regard to the economics of such a technique as scarification to control Poria root rot, the conditions under which the experiment was conducted are not those that are likely to be encountered in practice. In the first place, scarification as part of normal commercial forestry would be undertaken only in locations of infection foci and then only when entire tracts of forest were being logged. Protection costs, which under these circumstances would include scarification costs, would be applied to the entire operational area. In the second place, the logging and scarification in the experiment was contracted and the fee of $250.00/acre charged for scarification was scaled on a basis of current land-clearing costs. In actuality, it was lowered from current rates because the contractor was allowed the sale of merchantable timber available from the logging of the study area. It is unlikely that costs of logging company equipment and personnel would reach a level that is current for land-clearing. These two points indicate that the use of scarification in practice would be much less costly than in the experiment.

Planting costs are difficult to equate with present costs in practice for two reasons; first, the planting was undertaken by the Community Recreation class from the local high school at a nominal fee of $250.00; secondly, the planting was carried out at 5 x 5 spacing, which is much closer than planting is normally done on commercial sites of reforestation. However, the actual planting costs of $39.06/acre compare favorably with the cost of $71.00/acre interpolated directly from data by Smith and Walters (1957) and not reflecting the increasing costs in 1969.

To add to the benefits derived from scarification, apart from the preliminary results that point toward successful control of Poria root rot, the manner in which seedling survival is enhanced is worthy of note for the species used. Scarification prior to reforestation is not a widely used practice in British Columbia and the evidence presented here suggests that some advantages could be gained through more wide-spread application. In this connection, it was observed that the whole-tree method of logging apparently resulted in the burial of large numbers of Douglas-fir cones. The contained seeds germinated and, in July, created large carpets of seedlings. Unfortunately these seedlings will have to be removed to prevent disruption of the experiment, but they are indicative of a positive result that might accrue and reduce costs further by substituting thinning at a later date for planting with its attendant mortality.

Continuing study in the experiment will be devoted to further sampling of root populations, rates of decay of various sizes of Poria-infected roots, and to the effect of micro-flora on the small roots left in the soil following scarification.

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Fig. 1

PLANTING DESIGN

Poria weirii Root Rot Control Study

Scarified Area				Unscarified Area			
FIR BIRCH	FIR	CEDAR BIRCH	LARCH	CEDAR	PINE CEDAR	BIRCH PINE	FIR BIRCH
CEDAR FIR	PINE BIRCH	CEDAR PINE	BIRCH	PINE BIRCH	FIR PINE	PINE	SPRUCE
BIRCH	FIR PINE	PINE	FIR	CEDAR BIRCH	CEDAR	FIR CEDAR	CEDAR PINE
CEDAR	CEDAR BIRCH	PINE CEDAR	FIR PINE	FIR	FIR BIRCH	BIRCH	FIR
SPRUCE	CEDAR	FIR BIRCH	BIRCH PINE	FIR CEDAR	BIRCH	FIR BIRCH	PINE
FIR CEDAR	BIRCH	PINE CEDAR	FIR	PINE CEDAR	CEDAR BIRCH	PINE	FIR PINE
BIRCH CEDAR	PINE	BIRCH PINE	FIR BIRCH	FIR	FIR CEDAR	CEDAR BIRCH	BIRCH
FIR PINE	CEDAR	FIR CEDAR	PINE	FIR PINE	LARCH	CEDAR	PINE BIRCH

TABLE I

Tally of Standing Coniferous Trees in the Study Area Prior to Treatment

Tree	Tree	Area to be Treated (Scarified)			Control (Unscarified) Area		
Species[1] 6	Condition[2]	Number of trees	Diameter Range(ins)	Mean Diameter	Number of trees	Diameter Range(ins)	Mean Diameter
Douglas fir	Alive	933	0.5 - 35.5	6.5	966	0.3 - 33.0	6.5
	Dead	122	0.8 - 31.4	3.9	204	0.3 - 22.9	3.2
	Total	1055		6.2	1170		5.9
Lodgepole pine	Alive	563	2.1 - 18.0	6.7	27	2.8 - 12.1	6.8
	Dead	157	1.4 - 11.8	4.0	12	2.1 - 8.5	4.9
	Total	720		6.2	39		6.2
Western red cedar	Alive	8	0.5 - 2.9	1.4	14	0.4 - 16.0	2.7
	Dead	0	- -	-	0	- -	-
	Total	8		1.4	14		2.7
Total of all species	Alive	1504	0.5 - 35.5	6.5	1007	0.3 - 33.0	6.4
	Dead	279	0.8 - 31.4	4.0	2.6	0.3 - 22.9	3.4
	Total	1783		6.1	1223		5.9

1. Not recorded in the table are three Pacific yews with diameters less than 1.0 inches
2. Not recorded among the dead trees are 103 stumps for which diameters are not available. The stumps were not logging residue.

TABLE II

Seedling Survival Ten Months After Planting in Treated and Untreated Plots

Species	Number Planted		Percent Survival	
	Treated	Untreated	Treated	Untreated
Douglas fir	1137	1159	78.5	41.1
Lodgepole pine	1198	1136	84.7	56.6
Western red cedar	1079	1108	23.3	3.7
Birch	999	1222[1]	86.4	----
Spruce	167	171	95.2	36.8
Larch	165	157	80.0	41.4

1. Value represents the number scheduled for planting. Mortality assessment was not completed because of difficulties in distinguishing seedlings among other vegetation.

TABLE III

Root Measurements per Cubic Foot of Soil

Root Condition	Diameter Class (cm)	Depth of Sample -- 0-1 foot					
		Number of Roots		Length of Roots (cm)		Volume of Roots (cm^3)	
		Treated	Untreated	Treated	Untreated	Treated	Untreated
Group I - Roots infected with *Poria weirii* Murr.	0.00 - 1.00	4.09	0.40	52.99	9.77	7.75	3.41
	1.01 - 2.00	0.12	0.32	1.37	7.04	2.47	9.10
	2.01 - 3.00	0.02	0.08	0.26	1.67	0.87	7.15
	over 3.00	0.02	0.11	0.29	4.65	2.79	118.12
	Total	4.25	0.91	54.91	23.13	13.88	137.78
Group II - Roots infected with *Armillaria mellea* (Vahl ex Fr) Quel.	0.00 - 1.00	2.18	0.47	24.78	13.39	3.51	4.62
	1.01 - 2.00	0.11	0.29	1.22	7.08	1.83	8.94
	2.01 - 3.00	----	0.05	----	0.85	----	3.87
	over 3.00	----	0.05	----	1.50	----	23.25
	Total	2.29	0.86	26.00	22.82	5.34	40.68
Group III - Roots infected with other fungi	0.00 - 1.00	5.25	0.46	55.57	11.86	6.70	4.58
	1.01 - 2.00	0.53	0.27	5.19	11.42	6.99	21.25
	2.01 - 3.00	0.10	0.15	1.89	4.86	9.08	24.13
	over 3.00	0.02	0.02	0.94	0.36	26.00	2.92
	Total	5.90	0.90	63.59	28.50	48.77	51.88
Total of all infected roots	0.00 - 1.00	11.52	1.33	133.34	35.02	17.96	12.61
	1.01 - 2.00	0.76	0.88	7.78	25.54	11.29	39.29
	2.01 - 3.00	0.12	0.28	2.15	7.38	9.95	34.15
	over 3.00	0.04	0.18	1.23	6.51	28.79	144.29
	Total	12.44	2.67	144.50	74.45	67.99	230.34
Group IV - Roots with no apparent infection	0.00 - 1.00	14.87	3.11	177.53	92.50	25.78	20.63
	1.01 - 2.00	0.85	0.21	11.93	7.44	17.73	8.51
	2.01 - 3.00	0.02	0.01	0.47	0.15	1.80	0.55
	over 3.00	0.02	0.01	0.61	0.15	10.91	1.15
	Total	15.76	3.34	190.54	100.24	56.22	30.84
Total of all roots	0.00 - 1.00	26.39	4.44	310.87	127.52	43.74	33.24
	1.01 - 2.00	1.61	1.09	19.71	32.98	29.02	47.80
	2.01 - 3.00	0.14	0.29	2.62	7.53	11.75	34.70
	over 3.00	0.06	0.19	1.84	6.66	39.70	145.44
	Total	28.20	6.01	335.04	174.69	124.21	261.18

TABLE IV

Root Measurements per Cubic Foot of Soil

Root Condition	Diameter Class (cm)	Depth of Sample -- 1-2 feet					
		Number of Roots		Length of Roots (cm)		Volume of Roots (cm^3)	
		Treated	Untreated	Treated	Untreated	Treated	Untreated
Group I - Roots infected with _Poria weirii_ Murr.	0.00 - 1.00	0.65	1.04	9.85	11.29	1.43	3.95
	1.01 - 2.00	----	0.34	----	4.20	----	5.44
	2.01 - 3.00	----	0.02	----	0.56	----	3.28
	over 3.00	----	0.03	----	0.47	----	7.18
	Total	0.65	1.43	9.85	16.52	1.43	19.85
Group II - Roots infected with _Armillaria mellea_ (Vahl ex Fr) Quel.	0.00 - 1.00	0.39	1.18	5.24	15.66	0.60	3.23
	1.01 - 2.00	----	0.08	----	1.01	----	1.17
	2.01 - 3.00	----	0.02	----	0.28	----	1.11
	over 3.00	----	----	----	----	----	----
	Total	0.39	1.28	5.24	16.95	0.60	5.51
Group III - Roots infected with other fungi	0.00 - 1.00	0.97	3.11	11.81	28.03	1.43	5.03
	1.01 - 2.00	0.09	0.19	1.08	1.97	1.52	2.49
	2.01 - 3.00	----	0.03	----	1.01	----	5.13
	over 3.00	----	0.01	----	0.10	----	1.07
	Total	1.06	3.34	12.89	31.11	2.95	13.72
Total of all infected roots	0.00 - 1.00	2.01	5.33	26.90	54.98	3.46	12.21
	1.01 - 2.00	0.09	0.61	1.08	7.18	1.52	9.10
	2.01 - 3.00	----	0.07	----	1.85	----	9.52
	over 3.00	----	0.04	----	0.57	----	8.25
	Total	2.10	6.05	27.98	64.58	4.98	39.08
Group IV - Roots with no apparent infection	0.00 - 1.00	1.88	18.99	28.41	245.75	3.83	22.58
	1.01 - 2.00	0.09	0.32	4.95	7.32	6.67	10.62
	2.01 - 3.00	0.02	0.02	0.67	0.38	2.41	1.51
	over 3.00	----	----	----	----	----	----
	Total	1.99	19.33	34.03	253.45	12.91	34.71
Total of all roots	0.00 - 1.00	3.89	24.32	55.31	300.73	7.29	34.79
	1.01 - 2.00	0.18	0.93	6.03	14.50	8.19	19.72
	2.01 - 3.00	0.02	0.09	0.67	2.23	2.41	11.03
	over 3.00	----	0.04	----	0.57	----	8.25
	Total	4.09	25.38	62.01	318.03	17.89	73.79