

PROCEEDINGS OF THE 5th ANNUAL WESTERN INTERNATIONAL FOREST DISEASE WORK CONFERENCE

**Salem, Oregon
December 1957**



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CHAIRMAN'S WELCOME

Gentlemen, I know that I express your thoughts in stating the pleasure and satisfaction we experience on the assembly of our Western Forest Disease Work Conference. This, our 5th Conference, provides no exception. For the past year it has been my privilege to be your Chairman, and it is in this capacity that I welcome you here today.

During the last few months I have been concerned with a thorough-going analysis of the organization and affairs of our Conference. In so doing I was constantly reminded of the service this Conference can render to its members and the agencies to which its members belong, and indeed, has already rendered. I refer in particular to the Conference in its role as a medium to alleviate the isolation that obtains to the professional careers of many of us. It is indeed a distressing situation when one is obliged to work in an atmosphere lacking a companionship of ideas and activities. Hence, the creation of an opportunity and a suitable environment for discussion is a function of the Conference that transcends all others in my opinion. Such a role could prove to be the most durable component of our Conference structure. It is in this mood, a mood of cooperation and fellowship, that we have launched each of our Conferences. It is in this mood that we commence our 5th Conference today.

I would like to welcome those of you who are attending your first Conference. If you are engaged in forest disease research or in administering it I know you will contribute wholeheartedly to our discussions. If you are here only because of an interest in forest disease research please feel free to enter into the discussions that are to follow and give us the benefit of your professional opinions. You will find that the Conference is not a gathering of spectators.

Although the Conference professes to endorse an atmosphere of informality, we have, as usual, provided a framework of formality to channel our discussions towards timely topics. Hence we have a printed agenda. It is not intended, however, that formality dominate the atmosphere of this meeting. We will commence our discussions, as previously, with the notification of new projects, terminated projects, and new or modified techniques. I remind you that this is the part of our program whereby we traditionally "place our cards on the table" and expose our work and ideas to the scrutiny of fellow workers.

A lot of work has taken place behind the scenes to plan for this meeting, and as usual a few of our hard-working members have spent many hours to assure its success. The staff of the Portland Division of Forest Disease Research as a group deserve our thanks for their efforts. We have Dr. Gilbertson and his assistants, Dr. Hunt and Dr. Etheridge, to thank for the framework of our proposed discussions. We will have occasion to thank our discussion leaders as the meeting progresses. Henceforth, however, the meeting is largely in your hands and I commend its success to you.

G. P. Thomas
Conference Chairman

RESEARCH CAPACITY IN FOREST PATHOLOGY IN WESTERN CANADA

R. E. Foster

In this report Western Canada will be considered synonymous with the Provinces of Alberta and British Columbia, the region of Canadian representation to the Western International Forest Disease Work Conference. Within this region research in forest pathology can be considered to be the present or potential responsibility, in part, of industry, university, provincial forest services, and the Canadian Government.

Industry - Although cooperation is extended in various ways, no direct research in forest pathology is currently undertaken by the forest industries of Alberta or British Columbia. Problems of application, moreover, appear to receive periodic rather than continuous consideration.

University - There are two universities in Western Canada situated at Edmonton, Alberta and Vancouver, British Columbia. Although specific training in forestry and forest pathology is available only at the University of British Columbia, suitable training to the Master's level is provided in botany, plant pathology, and related disciplines at the University of Alberta. The University of British Columbia is unique among Canadian universities in that it holds a permanent chair in forest pathology within the Department of Biology and Botany. Beyond the activities of the professor of forest pathology, research in this field is carried out from time to time by graduate students in partial fulfillment of thesis requirements and, although with greater emphasis on related disciplines, by the staff of the Faculty of Forestry. Adequate research facilities are available in the Biology and Botany and related departments of the University.

Provincial Forest Services - Provincial forest service investigations directly related to applied research in forest pathology are carried out in Alberta and British Columbia. In both Provinces the major emphasis is directed to the accumulation of cull data which are translated in terms of net volume factors applicable to the provincial inventories. In Alberta the work is directed by a graduate forester and supported by seasonal staff. In British Columbia the work is directed by a graduate forest pathologist who is supported by a permanent staff of six and by a further complement of seasonal assistants. The British Columbia program is also supported indirectly through related activities of the Forest Surveys and Inventory Division, as for example, activities of coding and tally crews in recording general pathological conditions through reference to the occurrence to trees of specified decadence classes. Equipment and facilities are adequate and in keeping with functional requirements.

Canadian Government Departments - Two Canadian Government Departments are concerned with research in forest pathology in Western Canada. The first of these is the Department of Northern Affairs and National Resources which operates in British Columbia through the Forest Products Laboratory at Vancouver. Research in products pathology is but one of several fields investigated by this Laboratory. Other fields covered include, in part, timber engineering, preservation, chemistry, utilization, and wood structure. On occasion certain of the latter fields may bear directly, or indirectly, on research in forest pathology, as for example, studies by the Utilization Section relating to the analysis of defective logs and trees in terms of their lumber recovery. The staff assigned to specific research

in forest pathology consists of three research officers. Seasonal staff are assigned to complement field activities as required. Research facilities are adequate and likely will be expanded following completion of a new modern Forest Products Laboratory currently under construction in Vancouver.

The second Canadian Government Department undertaking research in forest pathology is the Canadian Department of Agriculture which operates Forest Biology Laboratories in Calgary, Alberta, and Victoria, British Columbia. Both Laboratories undertake general research in forest pathology, excluding only forest products pathology. The Victoria Laboratory operates within the Province of British Columbia, while the Calgary Laboratory accepts responsibility for the Province of Alberta, the National Parks of Alberta and British Columbia, and the Western Region of the Northwest Territories. Staffs currently assigned to research in forest pathology consist of five professional and nine technicians at Calgary and 10 professional and six technicians at Victoria. The staffs are supplemented by seasonal assistants as required. Facilities adequate to the undertaking of field and laboratory research are available.

Summary

In this review an attempt has been made to list centers and organizations actively engaged in research in forest pathology. Reference to the related disciplines of forest ecology, physiology, genetics, statistical research, etc., has been omitted even though these disciplines are complementary, if not essential, to the progress of research in forest pathology.

A review of projects at most centers would indicate that forest pathologists are generally assigned responsibility for more than one and occasionally for a considerable number of important problems. It is evident, moreover, that most Research Centers are withholding action on important problems towards which no attention can currently be directed. This review would indicate a need either for reappraisal of existing programs or expansion of professional and technical staff, or both. Quite apart from basic research in forest pathology, there is need for additional studies in application of present knowledge, for extension of disease surveys, and for experimental control operations. Although it is not readily apparent how this latter objective might best be accomplished, it would appear that there is room for expansion of existing facilities as well as for greater industrial participation than is now apparent.

APPRAISAL OF RESEARCH FACILITIES IN LIGHT OF FOREST DISEASE CONDITIONS
IN THE WESTERN UNITED STATES

T. S. Buchanan

I can see no point in my attempting a specific appraisal of forest pathology research in the western United States, disease by disease, or facility by facility, for you workers in the field are far more familiar with those details than I. In attempting to cover this topic even in general terms, however, I do want to go back a few years, for I think the appraisal of any current situation is necessarily closely related to what has gone on before. Research on forest diseases in the West is only about 50 years of age so the historical summary can be very brief. I will confine this resume to Federal activities, but even in so doing I will still, except for the relatively recent past, be covering the major activities in this field of research.

By letter of June 15, 1901, the Secretary of Agriculture authorized Hermann von Schrenk, Field Agent, Division of Vegetable Physiology and Pathology, USDA, beginning July 1, 1901, to conduct experiments and investigations "relating to disease of timber and fruit, forest, shade, and ornamental trees" at the Mississippi Valley Laboratory in St. Louis and throughout the Mississippi Valley and other western sections. By 1902 von Schrenk had published some "Notes on Diseases of Western Coniferae", and in 1903 he published on the "bluing" and the "red rot" of western yellow pine in the Black Hills and on the brown rot disease of the redwood.

The first permanent appointment of a forest pathologist to the far West came in 1910 when Dr. E. P. Meinecke was assigned to the San Francisco Regional Office of the Forest Service to work on management practices to decrease the incidence of heart rot and diseases in the national forests and on improvement of the salvage of infected stands. This initial cooperative effort met with such success that in the following year under similar arrangements Dr. James R. Weir was assigned to the Northern Rocky Mountain territory and Dr. W. H. Long to the Southwest. Again studies of the heart rots of living trees of commercially important species had high priority in these early studies as did also the dwarfmistletoes of the Southwest. Then in 1920 Dr. J. S. Boyce was assigned to initiate work in the Pacific Northwest where once again the study of heart rots had priority.

From these modest beginnings and others in the East, evolved what since 1954 has been the Division of Forest Disease Research within the U. S. Forest Service. Along the way, but being always in the Bureau of Plant Industry, this forest disease research organization has variously been known as the Laboratory of Forest Pathology (1907), the Office of Forest Pathology (1909), and the Division of Forest Pathology (1931).

Certain shifts of headquarters, program emphasis and, of course, changes in personnel, have been made since, so that today the Forest Service maintains Forest Disease Research on a full division status at all western forest experiment stations as follows:

Pacific Northwest	- Portland, Oregon
California	- Berkeley, California
Intermountain	- Ogden, Utah

With pathologists also assigned to
the Spokane Research Center and in

5.

cooperation with the Utah State
University at Logan
Rocky Mountain - Fort Collins, Colorado
With pathologists also assigned to
the Albuquerque (New Mexico) Forest
Insect and Disease Laboratory.

This Federal staff now totals 22 technically trained pathologists. Perhaps we should add one more man to this list to cover the work being done in Products Pathology at the Forest Products Laboratory in Madison, Wisconsin but directly of concern to our Western problems. Vacancies or new positions to be filled will bring this total figure to about 30 men within the foreseeable future.

To this Federal force let's add the forest disease research manpower that is active, or might be considered potentially active, in state agencies and private industry. In compiling this list I have admittedly done a bit of estimating, but in so doing I have deliberately attempted to err (if at all) on the plus side.

Man Years

Washington	2
Oregon	2
California	1
Idaho.....	2
Montana.....	1
All other western states.....	2

This gives an additional 10, making at the most a total of 40 men, irrespective of employing agency, working full time equivalent on forest disease research in the western United States. These men constitute our most important forest disease research facility.

At the stations where these Federal men are headquartered, some have reasonably adequate laboratory and related research facilities, some have only rudimentary facilities, and still others essentially none at all. This situation has been no serious handicap to those working strictly on applied field research, but has, and still does pose some problems for those technicians attempting to undertake some of the necessary fundamental forest disease research.

Forest pathologists employed by state agencies (including their various universities), and private industry generally have, or have available to them, considerably more adequate laboratory facilities. Close integration of effort, often through formal cooperative agreements, has made these laboratories or the products of these laboratories, available to all forest disease research agencies. Only through these means have even more serious deficiencies in fundamental research been avoided.

Now let's go back to the manpower situation again and try to get some idea of the size of the job these 40 men have to handle. First, taking figures from Chapter II of the Timber Resource Review ^{1/}, we find they are responsible for disease research (and disease detection and surveys) on the following areas of commercial forest land in the western United States, exclusive of Alaska:

^{1/} U. S. Dept. of Agriculture, Forest Service, 1955. Timber Resource Review, Chap. II, Domestic Supply of Forest Land and Timber (Preliminary Review Draft subject to revision).

<u>Forest Type Group</u>	<u>Millions of Acres</u>
Ponderosa pine	37.5
Douglas-fir	31.7
Lodgepole pine	14.5
Fir-spruce	13.6
White pine	5.4
Larch	4.4
Hardwoods	3.9
Hemlock-sitka spruce	3.5
Redwood	1.6
Pinyon pine-juniper	<u>.9</u>
Total	117.0

This figures out to be awfully close to three million acres of commercial forest land for each research forest pathologist to look after!

Look at it another way. Referring again to Chapter II of the TRR, the live saw-timber volume and growing stock on commercial forest land, softwood (mostly) and hardwood were as follows in the West in 1953:

	<u>Sawtimber</u> (billion bd.-ft.)	<u>Growing stock</u> (billion cu. ft.)
Pacific Northwest	749	146
California	360	67
Northern Rocky Mountain	167	43
Southern Rocky Mountain	<u>69</u>	<u>18</u>
Total	1,345	274

Interpreting this as we did the acreage figures, each research forest pathologist is responsible for the disease problems of a timber resource currently equivalent to 34 billion board-feet of sawtimber and 7 billion cubic feet of growing stock. Again, a rather staggering responsibility!

These figures give us some idea of the magnitude of the resource whose disease problems these 40 men are responsible for. But let's get even more realistic and see just exactly what impact diseases are having on this vast and valuable resource. Referring now to Chapter IV of the TRR ^{2/}, we find the disease situation in the West in 1952 was about as follows:

^{2/} U. S. Dept. of Agriculture, Forest Service, 1955. Timber Resource Review, Chap. IV, Factors Affecting Future Supply and Quality of Domestic Timber. A. Forest Protection Against Destructive Agencies. (Preliminary Review Draft subject to revision)

<u>Disease</u>	<u>Growth impact to:</u>	
	<u>Growing stock</u>	<u>Sawtimber</u>
	(Million cu. ft.)	(Million bd.-ft.)
Heart rots	309	1,928
Miscellaneous	205	983
Dwarfmistletoe	171	577
Douglas-fir root rot	96	454
Blister rust	46	274
Pole blight	14	61
Elytroderma needle cast	9	46
Total	850	4,323

Now I think we can really picture the importance of disease to the forest economy of the West and better appreciate the responsibilities resting squarely on the shoulders of each of these 40 research forest pathologists! Each can figure he is solely responsible for finding the whys and wherefores and ways and means for reducing annual losses amounting to 21 million cubic feet of growing stock and 108 million board-feet of sawtimber. This sawtimber volume alone represents raw material sufficient to keep a sawmill having a daily capacity of 100,000 board-feet running for over four years!

If we were to go back and read through the something like 3,000 publications relating to forest diseases in the USA that have been released in the past 50 years (a proportionately fair share of them of direct application to the West), we would find that considerable progress has been made and that the situation isn't as utterly hopeless as the quoted figures might make it first appear. We know a lot more about the important fungi and the etiology and epiphytology of the diseases they cause than was known even as recently as 10 years ago.

The work of the early pathologists was of necessity pretty much exploratory in nature - getting acquainted with the existent diseases, the forest tree species they were damaging, and their general geographic distribution. Of prime importance, too, was the determination of the causal organisms. Perhaps it would be better to refer to this phase of their work as Forest Mycology rather than Forest Pathology. True, there are still some voids (pole blight of western white pine, for example), but in general we are now pretty well familiar with the causal organisms responsible for both our epiphytotic and enphytotic forest tree diseases.

Gradually increased, too, has been our familiarity with the life histories of these various fungi and the various factors enabling them to be disseminated, infect susceptible host plants, and cause disease. We are not nearly so far along here as we are with the mycological phases of the problem but are continually seeking further and further refinements and more detailed knowledge. Unfortunately it has not always been possible to chart and adhere to an orderly plan of research, for some of our native diseases have assumed epiphytotic proportions and at least one introduced disease has similarly behaved. These have demanded immediate and priority attention. A brief outline of the work on white pine blister rust, which has been subject to research in the West for 35 years, will serve to illustrate this point.

The causal organism had already been identified when the disease was introduced into the West but local determinations had to be made for purposes of verification.

The relative susceptibility of the various 5-needled pines was determined.

The critical distance of spread from Ribes to pines was established and the relative susceptibility of the various Ribes was determined, forming the basis for biologically sound control recommendations.

The amount and rate of damages to pines of various classes were determined.

In general terms, the broad influence of various climatic factors on the spread and intensification of the disease was determined.

Now we are beginning to make microclimatic studies to determine the effect of those minute variations (both in time and space) of climate that ultimately determine whether or not and to what extent pines may become infected. Such information will tie in directly to the control program, pointing out areas where control efforts may be relaxed, areas where control effort must be increased, and areas where control may be utterly impracticable if not impossible.

We are not nearly this far along with other of our important western forest tree diseases. It is at least of academic interest to note here that some of the diseases which formed the basis of decision for originally assigning forest pathologists to western stations are still the subject of active and intensive research. It is essential that we improve our knowledge of the factors contributing to the spread and intensification of disease for the mere presence of a pathogenic organism does not constitute disease or entail damage. How does the causal organism develop and spread; what external factors trigger and condition these activities; how and under what conditions does the disease develop within the host and cause damage or death? These are phases of forest pathology wherein we are urgently in need of increased knowledge.

But even after we do become fully acquainted with the causal organism, the etiology and epiphytology of the resultant disease, and the details of host reaction, we still have not fully discharged our responsibilities. Only when this knowledge is converted into recommendations for control, through direct or indirect means, have we completed our job! These recommendations must be biologically sound, economically feasible, and such as can and will be put into practice by the managers of forest properties.

Converting the knowledge we do have on forest tree diseases into sound control measures seems to me to be one of the biggest current weaknesses in our forest disease research program. It is obviously true that we do not know all that is desirable about any forest tree disease; nevertheless, we certainly must know more than those foresters not technically trained in pathology but charged with the responsibility of managing forest properties. We must impart our specialized knowledge to them as fast as we acquire it, and point out how this can be used by them to aid in more efficiently managing their timber stands. Every day they have to make important decisions, often having enduring impact. Surely we can aid them with respect to disease problems. To do this effectively I think an essential first step is to impart to all foresters a keener appreciation of the importance of forest tree diseases and an awareness of these diseases when they encounter them on the properties under their management.

One factor that I feel often is responsible for what may seem to be lack of support for forest disease research from the public in general, including some forest managers, is the feeling of "so what - you find out all about these

diseases but you never control any of them". Control is not a direct responsibility of the majority of persons conducting research on forest tree diseases but a mere statement of that fact is not a satisfactory pacifier. Nor should we be seeking a pacifier. We need more strongly to indicate how the practicing forester can incorporate our findings into his silvicultural systems and management plans and how he can effect a measure of control through those means. Irrespective of whether or not control is obtained by any means or by anyone, knowledge of existent diseases, their modes of behavior, and the current and potential losses they cause is essential information to the conduct of any well-managed forest enterprise. Management, cutting cycles and cutting budgets, and logging layouts can accurately be planned only when based on a reliable inventory. How can a reliable inventory be obtained if the inroads of disease are ignored? As timber values increase and economic situations possibly create a narrower and narrower margin of profit for timber operators, precise evaluation of disease losses will become even more critical. How long would a grocer be able to stay in business if, for example, he had purchased 100 bags of potatoes from a wholesaler and upon taking inventory a month later ignored the fact that 10 of the bags remaining had rotted in the meantime?

What can and should be done to improve the forest disease research situation? I think it quite obvious that the total technical manpower currently available to conduct research on forest tree diseases in the West (as well as in other parts of the country) is woefully inadequate. It is obvious, too, that as we continue our various lines of research the need for increased emphasis on fundamental research as a base from which to launch our applied research, will become more and more critical. This calls for increased and improved laboratory facilities as well as increased manpower.

The Forest Service has plans for increased efforts on forest disease research. It is giving serious consideration to the establishment of one or more laboratories for fundamental research in forest biology. These plans include greenhouses, controlled environment chambers, and other facilities for essential work in forest pathology. In submitting our plans for a 10-year expansion program, we proposed, as a minimum national requirement by the end of the period, these numbers and categories of increased staffing for research on forest tree diseases:

Forest pathologists	57
Foresters	4
Wood technologists	3
Mycologists	3
Plant physiologists	3
Nematologists	2
Bacteriologists	2
Soils scientists	3
Virologists	2
Biochemists	2
Photogrammetrists	2
Biometricians	2
Climatologists	2
Radiologist	<u>1</u>
Total	88

These numbers are for the country as a whole but still represent better than double our present staff. They would be assigned where and as needed, with the West, of course, being assigned a quota commensurate with the relative needs.

It is even more encouraging to note the increased attention being given to forest tree diseases by private industry and by the States and their university systems to forest disease research and to the training of forest pathologists.

Finally, the most encouraging feature of the whole forest disease problem in the West is the wonderful cooperation that has long been established and continues still further to improve amongst all agencies concerned whether they be government or private. I know of no other field of forestry research that has attained such a high degree of cooperation and coordination of effort as has ours. When I make this statement I do not confine myself to the western United States but cut across international borders to include our good neighbors in western Canada and in Mexico as well. I feel certain that meetings such as this one will continue to aid in fostering this fine spirit. This esprit de corps is essential if we, this small group of pathologists, are to fulfill our obligations.

LETTER FROM DR. JULIO RIQUELME INDA

Mr. Chairman, Gentlemen:

The Mexican Forestry Association of which I am President, conveys its most cordial greetings to this Honorable Assembly of the Fifth International Convention for the study of forest plagues and diseases, and wishes to express its sincere desire that the work undertaken today by the Fifth Convention meets with success and that the results will be beneficial to the health of forests and natural resources, the existence of which is essential to the life of all the people on earth.

As declared at the Fourth Convention held in El Paso, Texas during November 1956, Mexico is highly interested in the studies being made by other countries on plagues and diseases affecting trees, particularly in the work done by the United States and Canada, as many forest species are common to the three countries and, therefore, numerous vegetable and animal parasites affecting same are also common to all three.

My country has not neglected this aspect of silviculture. Although not to the required extent or with great resources, for many years Mexican naturalists and conservationists have been tackling forestry problems, principally those connected with insect and arthropod plagues and bacterial, fungous, or virus diseases. Such contribution by Mexico may be profitable at some time when the forest entomologists and pathologists from the United States, Canada, and Mexico coordinate the results of their studies and experience in the field of direct and practical action to combat said parasites of the forest.

I avail myself of this opportunity to advise you that the Mexican Department of Agriculture includes a Forestry and Hunting Subdepartment under which the

Institute of Forestry Research is operated, and that last month, in October, there commenced the erection of a building especially designed to shelter said Institute. These quarters will be properly equipped for all kinds of research and study to be undertaken in connection with the anatomy of woods, drying, and preservation, research as to their physical, mechanical, and chemical properties, and best use of same in the chemico-pharmaceutical industry, building, paper and cellulose manufacturing, etc. Of essential interest is the impetus the Institute will give to the parasitological study of standing trees and industrial products derived from same.

In my opinion, the work planned by the Institute of Forestry Research will require the collaboration of various private organizations in Mexico which altruistically and enthusiastically work for the protection and maintenance of our natural forestry resources. Also, technical assistance from other scientific organizations which have made great progress in the subject matter, much as the different organizations represented in this Convention, will be needed. An exchange of forest parasitological information will be to the mutual advantage of the three countries.

Therefore, I beg to recommend the creation in Mexico (of the three countries the least developed in this aspect of economic science) of a semi-official organization supported by subsidiary contribution of the governments of the three North American countries, to collaborate with the Institute of Forestry Research, furnishing specialized technical personnel. The Institute would provide laboratories, equipment, and fields of research in wooded areas appropriate for the study of plagues and diseases affecting forests so as to establish reciprocal relations and information from parasitologists in benefit of the three countries.

Should this proposition be worthy of consideration by the Fifth Convention, the Mexican Forestry Association would take the necessary action before the Government of Mexico to carry out the idea. The persons present at this Convention, from Canada and the United States, would likewise take such action as should be required before their respective governments.

It is the desire of the Mexican Forestry Association, and mine personally, that on some future occasion, one of these Conventions be held in my own country, in Mexico City, one of the great cities of the world, with centuries of tradition behind it and worthy of a visit by our excellent friends from Canada and the United States and travelers from all continents.

I believe there is much to see and admire in Mexico, a country of contrasts retaining much of its old pre-Cortez and colonial culture and feeling simultaneously with the feverish restlessness of a vigorous country growing rapidly, with shining ambitions for a better future.

(for action taken on this letter, see report of business meeting, page 128)

DAMPING-OFF AT FOUR BRITISH COLUMBIA FOREST NURSERIES AND
SOME ASPECTS OF ITS CONTROL

P. J. Salisbury

Some differences in environment and differences in damping-off at the nurseries. The four forest nurseries in British Columbia are located in three climatic regions ^{1/}. They differ in damping-off hazards accordingly. Although all are apparently cool enough ^{2/} to escape disastrous epidemics, the two with warmer growing seasons are more subject to damping-off than the other two. Of the warmer, the Cranbrook nursery, which in places has neutral or alkaline soil, sustains greater damping-off losses than the Duncan nursery, which has moderately acid soil. Post-emergence losses at both may take about 20 percent, but Cranbrook has the greater pre-emergence losses. Of the cooler two sites, the Green Timbers nursery sustained up to 35 percent damping-off losses in 1954 but very light ones since, and the Campbell River nursery has sustained post-emergence damping-off losses in the order of 2 percent although seedling emergence has frequently been limited by some unknown cause or causes. Fungi usually isolated from damping-off have been: at Cranbrook, Pythium sp.; at Duncan, Rhizoctonia solani early in the season followed by Fusarium oxysporum; and at Green Timbers, R. solani. At Campbell River, R. solani and Fusarium spp., though represented, accounted for no more than a third of the isolates from apparently damped-off seedlings. The seedlings grown have been Douglas-fir at all four nurseries and, in addition, yellow pine and white or Engelmann spruce at the Cranbrook nursery.

Application of fungicides at or before seeding time. Increases in stand of seedlings have occurred with few exceptions when thiram or zineb have been used, preferably dusted on wet seed or pelleted on. Captan, ferbam, phygon, spergon, bordeaux mixture and the soil partial sterilants, allyl alcohol, chlorobromopropene, vapam and mylone, have been less effective for increasing stands of seedlings. However, soil sterilants are desirable for further testing against damping-off since they have shown an advantage in decreasing stands of weeds significantly.

Partly because of differences in disease intensity, a given fungicide has varied in apparent effect at different times and places. Thus, four months after the application of thiram at sowing time, associated increases in stand have ranged from test to test as follows: at Cranbrook from 5% to 228%; at Duncan from 2% to 14%; at Green Timbers from 0% to 45%; and at Campbell River from -36% to +10%.

^{1/} Cranbrook is in a Humid Continental-Cool Summer province, Duncan is in a Cool Summer Mediterranean province, and Campbell River and Green Timbers are in Marine West Coast provinces. (J. D. Chapman. The Climate of British Columbia, Fifth British Columbia Natural Resources Conference, 1952).

^{2/} Duncan, the warmest nursery, has the following average daily means: for May, 55° F.; for June, 61; and for July, 65. (25-year averages).

Application of fungicides after emergence of seedlings. Increased stands have been obtained by applying fungicides four to eight weeks after sowing. In one test at Duncan, application of either thiram or zineb on cover soil eight weeks after sowing improved overwintering. Some of the seed had been coated with thiram, resulting in increased stands. The benefits from cover soil treatments made eight weeks later were in simple addition to this effect, with no interaction. The cover soil treatments were aimed at Fusarium oxysporum. Presumably if this fungus were inhibited tree roots would be freer from decay and the trees more able to withstand effects of winter freezes in the nursery.

Practicability of chemical control of damping-off at B. C. forest nurseries. Because of moderate damping-off losses, use of fungicides in B. C. nurseries has been regarded as a marginal operation, economically considered. Small-scale tests have indicated the value of certain fungicides where considerable damping-off is of frequent occurrence. Sometimes post-emergence damping-off is slight but seedling emergence is unsatisfactory. Fungicidal control measures have been effective in such cases at one nursery, indicating pre-emergence damping-off and its control, but ineffective at others, suggesting unsatisfactory cultivating methods or poor soil conditions for germination and emergence. Without high damping-off hazards, the insurance value of using fungicides should still be considered in the following circumstances:

1. Where valuable and scarce elite seed is to be used.
2. In poor seed years when there is a shortage of good seed.
3. When nurseries are being used to capacity so that extra beds cannot be sowed to cover possible losses.
4. When seedling emergence has been unsatisfactory and pre-emergence damping-off has not been eliminated as the cause.

In large-scale tests made by the B. C. Forest Service, pelleting seed with thiram has had less beneficial effect than in the small-scale tests cited above. The B. C. Forest Service is nevertheless using thiram on a fairly high proportion of seed at some of their nurseries.

Potential utility in the forest of fungicidal seed treatments that are effective in nurseries. The in-the-forest effectiveness compared to in-the-nursery effectiveness of seed treatment with fungicides is not known. In the nursery, besides protecting against damping-off, pelleting with thiram appeared sometimes to protect seed in the ground for one year, a kind of protection that might be valuable under forest conditions unfavorable for germination. In one test with unstratified seed in seedbeds at the Campbell River nursery, the stand four months after sowing averaged 25 per sq. ft. for controls and 23 per sq. ft. for seedlings from pelleted seed, while thirteen months after seeding the stands had increased to average 34 per sq. ft. for controls but 61 per sq. ft. for seedlings from pelleted seed.

In direct seedings to date by J. M. Finnis, B. C. F. S. Research Division, no appreciable increase in stand resulted from adding thiram to mixtures pelleted on Douglas-fir seed. However, the addition of thiram to seed pelleting mixtures has been recommended by the Wildlife Research Laboratory of the U. S. Fish and Wildlife Service.

TESTS TO CONTROL ROOT ROT OF 1-0 PONDEROSA PINE

Ernest Wright

The control of root rot of 1-0 ponderosa pine and other species has commanded the attention of forest pathologists for many years. We still lack much of the basic and fundamental information to completely understand the problem. This is largely due to the lack of concurrent field, greenhouse, and laboratory tests. Tint, in 1945, published a series of papers in Phytopathology on his studies of Fusarium as the cause of damping-off of conifers. Only brief mention was made of Fusarium root rot. An attempt will be made in this paper, therefore, to discuss Fusarium as the cause of root rot of western pines.

Back in the early thirties, the Forest Service established a pine nursery at Susanville, California. Almost immediately excessive root rot losses occurred in one-year ponderosa and Jeffrey pine seedbeds. It was necessary to determine the cause of the root rot and to develop control measures. After several years of study, the following tentative conclusions were reached:

1. Losses were largely due to a root rot caused by a Fusarium.
2. Usual control measures, such as soil acidification, the application of mercuricals, formaldehyde, etc., were ineffective.
3. Losses from root rot were greatest during July and August.
4. Surviving two-year-old seedlings showed no pronounced detrimental effect from root rot.
5. Fall-sown beds had considerably less root-rot losses than spring-sown beds.

In limited laboratory tests, it was found that there were three strains of the same species of Fusarium. We called them the unpatriotic pink, white, and blue Fusaria. The white strain grew fastest on PD agar, but they all appeared about equally virulent in inoculation tests. The white and blue strains grew best in a liquid medium at pH 6.0, and the pink strain at pH 6.4. The optimum temperature for growth in petri-dish cultures was about 22° C, but they also made fairly good growth at 30° C. The pink strain made best growth at the low temperatures of 5° and 15° C. The relation of soil temperature to virulence was not determined at that time, but it appeared probable that the various strains were pathogenic over a wide range of soil temperatures, particularly high temperatures.

To bring the subject more up to date, the Forest Service opened another pine nursery east of the Cascade Range at Bend, Oregon, in 1947. The site was very similar to the one at Susanville, with a sandy loam soil typical of the juniper-sagebrush association. During the first year of major production, 1-0 ponderosa pine seedlings showed considerable loss from root rot. Forest Disease Research was called in to determine the cause and to institute control measures. The following discussion, therefore, is based on tests made at Bend and in the greenhouse, using Bend soil.

A Fusarium was isolated from diseased ponderosa pine seedlings and identified by Snyder as F. oxysporum f. pinii. The pH of the soil averaged 6.8, varying from

about 6.5 to 7.0. The water used for irrigation is about pH 7.2. Losses were heaviest during July and August. During these months soil temperatures run well above 100° F. The entire nursery is underlain with lava rock, and the tillable soil is about 18 inches deep. Root-rot losses have varied considerably from season to season but have been heaviest the first year that the soil is put under cultivation and during dry seasons. The soil has been analyzed for N, P, and K, and found to be relatively low in available nitrogen but fairly adequately supplied with phosphorous and potassium. The nematode count is extremely low, according to an Oregon State nematologist.

It is my theory that the seedlings are most susceptible to root-rot infection at about the time the first true leaves are formed. If this occurs when soil temperatures are high, the Fusarium causes heavy damage. Greenhouse and field tests lend considerable support to this conclusion.

Preliminary greenhouse soil temperature tests, using Wisconsin-type temperature tanks, gave the following results for unstratified ponderosa pine seed in 3-pot replications:

<u>Soil temperature</u>	<u>Average no. seedlings</u>	<u>Percent with root rot</u>
62° F	55	8
78° F	47	28
92° F	46	33

Steam-sterilized soil was inoculated with Fusarium and reisolutions made from diseased seedlings. This admittedly was a small test and needs repeating with unsterilized as well as sterilized soil. It does indicate, however, that F. oxysporum f. pini is most virulent at high soil temperatures. In practice, one method of reducing soil temperatures in the seedbeds is to water frequently. Shading has not been effective.

The importance of rotation crops in the disease control program has also been tested. A typical field test made in 1951, based on 90-foot row counts, gave the following yield per lineal foot:

<u>Rotation crop</u>	<u>Net yield no.</u>	<u>Root-rot loss no. (per lineal ft. of bed)</u>
Wheat	156.4	8.0
Red clover	92.6	28.7
White clover	49.1	29.0
Rye and vetch	83.6	20.4
Rye	130.1	43.2
Check (untreated)	120.5	22.5

The same source of ponderosa pine seed was used throughout and the depth of sowing was kept as nearly comparable as possible. There were some undesirable variations between plots, primarily due to watering. However, wheat has consistently proved to be a desirable rotation crop and regularly reduces Fusarium root rot of ponderosa pine.

The benefit of adding organic matter to the soil before sowing has been shown in several tests. The best results have been obtained during occasional years when early damping-off was also severe. The tests of 1953 (5-plot replications of 4 square feet each) for this reason were especially indicative. These are summarized below, based on untreated checks.

	<u>Fall application, percent</u>	<u>Spring application, percent</u>
Old sawdust (100 cu. yds. per A.)	92	102
New sawdust	88	122
New sawdust + $\text{Al}_2(\text{SO}_4)_3$ (1 oz. per ft. ²)	156	118
Sucrose (1 oz. per ft. ²) + $\text{Al}_2(\text{SO}_4)_3$	150	79
$\text{Al}_2(\text{SO}_4)_3$	172	149
New sawdust + ammo. phos. (200 lbs. per A.) + $\text{Al}_2(\text{SO}_4)_3$	213	141

These are above average for several other test years. Some years have been better and some not as good.

The theory behind the application of sawdust prior to sowing is that it temporarily depresses the soil nitrate nitrogen and thus reduces the virulence of the root rot Fusarium.

It is unnecessary to enumerate the variations in the tests that have been made to control Fusarium root rot. They have included acidification, nitrification, fumigation, application of various organic and inorganic chemicals, testing of antagonistic organisms, rotation crops, mycorrhizal inoculations, and the addition of several types of organic matter. Also included has been depth and density of sowing, size and source of seed, and time of sowing.

At present, fairly satisfactory control is obtained by a combination of several treatments. When new areas are brought under cultivation a cereal rotation crop, preferably wheat, is grown for one season. The wheat is turned under in the fall, and 100 cubic yards of fresh pine sawdust to the acre is disced under prior to sowing, either in the fall or early spring. The seedbed area is acidified with 1000 to 2700 pounds of aluminum sulfate per acre plus 200 pounds of ammonium phosphate. The seed is sown at a standard depth in one-half of all beds in the fall, and in the other half in early spring. If additional sowings are needed, they are held up until early or mid-August. Sowings in May or June have generally resulted in heavy root-rot losses. The newly sown beds are watered normally during the early part of the season and watered heavily during July and August. Watering is discontinued soon after September 1. Heavy watering is deemed necessary to keep soil temperatures below 90° F during the heat of the summer and to maintain good turgor of the seedlings.

With this method of treatment, 1-0 ponderosa pine seedlings have a well-developed root system with abundant mycorrhizae. Field survival of planted test stock has been excellent.

GENERAL CONSIDERATIONS OF THE PHYTOPHTHORA ROOT-ROT PROBLEM

Lewis F. Roth

Your speaker's attention was first actively turned to the *Phytophthoras* as nursery parasites in 1950 when he was asked by a research forester whether or not it was desirable to ship Port-Orford-cedar planting stock from forest nurseries at Corvallis, Oregon, and Wind River, Washington, into the native Port-Orford-cedar region of southwestern Oregon. This was a reasonable inquiry inasmuch as the forest nurseries were located in an area known to be more or less generally infested with the destructive cypress root rot *Phytophthora*. This fungus, if it occurred at all in the native cedar region, had not as yet made its presence known.

The nurseries were free of the fungus at that time and decisions made then are not pertinent here. The incident, however, suggests that the *Phytophthoras* are fungi of concern to the forester and their occurrence in the nurseries of the Pacific Coast states may be of special significance. This conclusion was dramatized by events in Coos and Curry Counties, Oregon, in the months soon following our discussion.

During the early spring of 1952, we found *Phytophthora lateralis* killing naturally established seedlings at the city of Coos Bay, and by 1954 the fungus was widely scattered along the coastal shelf throughout the length of the commercial Port-Orford-cedar region. Dying trees were especially apparent along the roads and highways, lakes and streams, and the many estuaries of Coos Bay. Concentrations became numerous in the towns and around the farmsteads.

In 1951, an infected tree was found in the stock of a North Bend nursery. While it was not possible to follow the subsequent history of this nursery and its stock, this occurrence just preceding the epiphytotic outbreak casts suspicion on the part played by this nursery and others both within and outside the cedar region. As you know, there is a great deal of inter-nursery movement of rooted plants in the ornamental trade.

Up until the outbreak in the forests of the south coast, *Phytophthora lateralis* had been distinctly a parasite of commercial nurseries and of ornamental plantings originating in these nurseries. Losses have become progressively greater ever since the discovery of the parasite in 1938 and may have begun in the Seattle area at least as far back as 1923. Ornamental Port-Orford-cedars which once occupied a leading position in the nursery trade now have been reduced to a position of relative unimportance with many nurseries discontinuing production altogether.

While a shift to nonsusceptible species may help the individual nurseryman, it is not a solution to the greater problem. The parasite persists in the infested soil and may be carried on the roots of any plant whether or not infected. The reality of this situation is well shown by the many cases of mortality to be found among widespread farm windbreaks planted with trees from the disease-free forest nurseries.

Something should be said at this point of the fungi involved. Several species of *Phytophthora* attack tree roots but with us *P. lateralis* and *P. cinnamomi* are the fungi of immediate concern.

P. lateralis is a soil-inhabiting parasite, pathogenically limited to the genus Chamaecyparis. It was originally described in 1942 by Tucker and Milbrath on the basis of its typically Phytophthora-like zoospore emission and distinctive chlamydospores. We have subsequently found the sexual stage and an aerial habit which develops under certain special conditions.

P. cinnamomi, also a soil inhabitant, was described by Rands in 1922 from a cinnamon tree in Sumatra. This fungus is of worldwide distribution or at least has become so in the milder climatic regions. It attacks a wide range of woody plants. Under experimental conditions these include Douglas-fir, white fir, noble fir, western hemlock and other important commercial forest species of this region.

P. cinnamomi was first noted in Oregon in 1948, and, during the year or two that followed, reports of the fungus in ornamental plantings and commercial nursery stock became increasingly more common, as had been the pattern with P. lateralis a decade earlier.

P. cinnamomi is a new fungus in the experience of the commercial nurserymen and poses a very serious problem for these people and possibly also for foresters. If this is an introduced fungus and if it is likely on Douglas-fir to follow the chain of events which gave rise to the P. lateralis epiphytotic in the native cedar, there are real grounds for concern.

Three general areas appear endangered: the commercial nursery, the forest nursery, and forest productivity.

Assuming that the fungus is a recent introduction into the region and that it is as pathogenic on Douglas-fir as reported, we are confronted by the following probabilities:

1. A rapid buildup in commercial nurseries where losses will be great and largely inescapable because of damage to a wide variety of ornamentals.
2. Eventual infestation of the forest nurseries which could necessitate abandonment.
3. Invasion of Douglas-fir forest lands where, if damage is comparable to the attack of P. lateralis on Port-Orford-cedar, great losses may be expected.

With these high values at stake, many agencies and individuals have joined in a common effort, at various levels of participation, to evaluate the disease potential and to achieve some means of practical control. Representatives of these agencies meet at least once a year at a "Phytophthora Conference" for planning and evaluation purposes.

Survey responsibility for P. cinnamomi so far rests largely with the State Department of Agriculture because of the present known limitation of the fungus to the commercial nurseries. Responsibility for survey of P. lateralis is met by the Pacific Northwest Forest and Range Experiment Station. Significant contributions to the work are in progress by industry and the Oregon State Department of Forestry through colored aerial photography.

Experimental and observational study of the two diseases has been in progress for several years at Oregon State College. Information relating to control is a significant part of the program. This work has been aided by financial support from the State Department of Forestry, the Bureau of Land Management, and the State Nurserymen's Association, and has been encouraged by the Northwest Forest Pest Action Council. Control of both diseases in the nurseries of Oregon at least is attempted by the State Department of Agriculture and by the individual nurseryman. Field control of P. lateralis appears to have passed the point of economic practicality.

Much of this effort may be shadow-boxing because of our limited knowledge of the actual nature of the threat.

It appears that the assumptions suggested earlier in this report that the fungus is newly introduced and that it is dangerously pathogenic on Douglas-fir cannot be made without reservation. Evidence as to whether or not we are dealing with an introduced or a native fungus is contradictory; moreover, the aggressive parasitism of the fungus on Douglas-fir under field conditions remains to be established.

Because of the currently peculiar economic situation in the Port-Orford-cedar industry, I will not attempt recommendations for the P. lateralis problem. With P. cinnamomi, however, certain needs are apparent.

We must determine with certainty whether or not we are dealing with a native or an introduced parasite and in either case we need greatly to increase our knowledge of the distribution of the fungus. Factual knowledge of the parasitic potential of the fungus under forest conditions is urgently needed. If pathogenesis occurs at all, then the factors limiting or favoring its development should be promptly investigated. Until these two points can be clarified, every effort should be made to contain the disease within the nurseries and ornamental plantings where it now occurs.

As might be expected, even these broad objectives cannot be easily achieved.

Proof of endemic occurrence and distribution mapping must be based on very extensive sampling because of the wide geographic area concerned. This job is difficult because of the lack of an absolute or highly accurate detection technique. The variability of the fungus and its convergence upon its near but innocuous relatives further complicate the matter.

Evaluation of the damage potential under forest conditions ultimately can be made only in the field. Yet because of the uncertainty of the threat, forest landowners and administrators are reluctant to encourage investigations on their properties.

Containment of known or undiscovered infections is limited by many obstacles. There is no legislative authority for destroying or limiting shipment of plants in infested soil. Where the problem comes to the attention of the nursery inspection service, the inspectors usually "meet the growers halfway". Plants showing symptoms are destroyed while those from soil less certainly infested enter freely into trade. The degree of restriction of movement of stock is largely regulated by the grower's understanding of the problem, his knowledge of the extent of his infestation and by his ethical and financial circumstances. In a few cases infested land has been retired from nursery production but this appears to be the exception.

The need for greatly increased information in all areas concerning P. cinnamomi is apparent.

Our present research is directed primarily toward problems of fungus survival, spread and pathogenesis in forest soils and the conditions that affect these activities. While it is not possible in this presentation to consider the many details of research, the questions, thoughts and suggestions of the Conference are eagerly invited.

Moderator's Summary

In soils low in organic matter severe losses from damping-off and root rot may be expected. Fumigation of the soil followed by inoculation by mycorrhizal fungi will eliminate these losses. Less drastic and less costly methods are preferred. Organic additives, such as cover crops or sawdust, have been used successfully. Sawdust material has proven to be better and cheaper, if applied properly.

In greenhouse tests, forest soils have been used to raise flats of Douglas-fir seedlings without damping-off losses. Heavy mortality was experienced using "normal" soils.

Severe root-rot losses in two forest nurseries may be attributed in part to the fact that the nurseries are in poor locations for growing forest trees.

It was emphasized that each nursery is a separate problem and no single corrective measure can be prescribed for all. The nurseryman needs to know the specific causal organism--then he can apply the proper corrective treatment.

Tests to control losses biologically, using Trichoderma and other antagonistic organisms, have not been successful as yet.

MANAGEMENT CONSIDERATIONS OF LODGEPOLE PINE IN ALBERTA
AS INFLUENCED BY HEART ROT

V. J. Nordin

The purpose of this presentation is to review the subject of heart rot in lodgepole pine in Alberta and to indicate the influence of this type of disease in the management of this tree in this Province. While there will be no attempt to consider this subject beyond present regional conditions, I believe this brief review may prove interesting to others concerned with the management of this species.

Values of lodgepole pine. The range of lodgepole pine in Alberta includes generally the east slopes of the Rocky Mountains and the foothills. This tree is one of the most important coniferous species in the Province and comprises approximately 60 percent of the volume in the Rocky Mountain region.

The recent establishment of a pulp mill 40 miles east of Jasper has greatly increased the economic value of this tree since approximately 65 percent of the pulpwood used is lodgepole pine. This mill currently produces 400 tons a day and its capacity is expected to increase to a thousand tons a day within the next three years.

Besides pulpwood, other major uses for lodgepole pine include lumber, railroad ties, and power poles. Less important products are roundwoods such as mine props, fenceposts, corral rails, and fuel wood. The aesthetic values of this tree are very high when it is considered that the predominant forest tree cover in the Rocky Mountain National Parks is comprised of even-aged stands of lodgepole pine largely in the range of 55 to 90 years. Watershed values are extremely high because all major rivers flowing to the Prairies originate in the East Slopes of the Rocky Mountains.

The identity of heart-rot organisms and their incidence. The pertinent literature on this subject until April 1955 has been reviewed(6). Since that time, additional reports for Alberta have been prepared (2, 3, 4, 5). Further cull analyses of 422 trees in 1957 bring the total number of lodgepole pines examined to 712. Other work in progress, which may provide an interesting comparison of fungus populations, are the studies by Wright announced in last year's Proceedings of this Conference.

Our studies have shown that most of the heart rot in lodgepole pine in Alberta can be assigned to one fungus, Stereum pini (Schleich ex Fr.) Fr. A minor organism, surprisingly enough, is Fomes pini (Thore ex Fr.) Karst., along with Stereum sanguinolentum Alb. & Schw. ex Fr., Polyporus anceps Pk., Polyporus tomentosus Fr. Flammula conissans Fr., and Coniophora puteana (Schum. ex Fr.) Karst. Until the age of 90 years, at least 90 percent of the decay is firm incipient and called red stain or red heart. This fact is important when considering the relationships of heart rot and the management of lodgepole pine for various marketing purposes.

The occurrence of decay in stands 85 to 90 years old is high. The rate of infected trees is approximately 85 percent and each infected tree averages at least two separate infections. Although no information is yet available on the relationships of site and decay for this species, decay-ecology studies are scheduled for initiation in 1958. The 712 trees already examined will form part of the basis for these investigations.

Infection courts. In the predominating age classes of lodgepole pine in Alberta, most of the infections originate in branch stubs. Where stands have been injured by ground fire, however, basal fire scars assume some importance as infection courts. In study areas where 86 percent of the trees had 33-year-old basal fire scars, branch stubs served as infection centers for 60 percent of the infections and fire scars for 21 percent of the infections. Because of their basal location, however, these infections in fire scars resulted in 46 percent of the volume of decay compared with 39 percent for branch stub infections. Minor courts of infection include falling tree scars, roots, frost cracks, and crotches. From the standpoints of heart rot and management, therefore, branch stubs and fire scars are the important infection courts.

To summarize the significant points in the background information just reviewed, the following should be kept in mind as we discuss a few aspects of heart rot and its influence on the management of the present stands of lodgepole pine in Alberta:

1. First, lodgepole pine stands are even-aged and the predominating age range of commercial forests is 55 to 90 years.
2. Second, the important products for this tree are pulpwood, lumber, ties, and power poles.
3. Third, very little advanced crumbly decay occurs, and, in the predominating age classes, 90 percent of the decay infections can be expected to be firm incipient red stain. Further, the identity and incidence of causal organisms such as Stereum pini can be important in forest management.
4. Fourth, branch stubs and fire scars are the important infection courts for decay organisms.

Discussion. Because the stands in Alberta are even-aged, clear cutting is recommended as the best procedure to reduce the significance of heart rot in lodgepole pine. This is based on the principle that the incidence and volume of decay increase with age and that stands can be logged before decay becomes serious. Other factors such as the ultimate product of manufacture (e. g., pulpwood, lumber, ties, power poles) will qualify the stage at which decay becomes important. For example, a stand of lodgepole pine may have a high incidence of red stain with little advanced decay and, if utilized for poles, cull through stain and decay would be negligible according to regulatory standards (1) which permit firm red stain in poles. If the same stand is utilized for lumber, however, losses would result because of stain degrade. Increased bleaching costs may occur if this material is used for pulpwood.

The fact that 90 percent of the decay infections can be expected to be firm red stain presents another problem in management in this region because so much of the red stain is caused by Stereum pini. The predominance of this fungus is significant because the development of standards for poles and ties exhibiting red stain are based on experimental results with Fomes pini. At present, very little is known about S. pini in living trees and particularly its effect on the quality, strength, and durability of various forest products in service. Before a realistic approach to management may be made, therefore, studies are needed to determine the required facts for S. pini.

With the knowledge that branch stubs and fire scars are the major infection courts for decay fungi, can this knowledge be utilized in management procedures? Unfortunately, for the present at least, branch stubs do not provide a suitable index for estimating hidden decay in the predominating age classes in Alberta. In stands that have been injured by ground fires, however, the resulting basal fire scars may prove important as infection courts. Studies (4) have shown a highly significant correlation between the incidence of infections and the size of the fire scar; an index can be calculated by multiplying the length of scar by the width of the scar measured at 12 inches from ground level. In other words, the chances of infection increase with a corresponding increase in scar area, and this knowledge can be applied to advantage to the management of stands so injured.

Regarding fire scars, heart rot, and management considerations, investigations have shown that 33 years following a ground fire, the percentage of scarred trees with infections in the scar was 46 percent and almost no advanced decay was in evidence. Because of the relatively high incidence of infections originating in scars, it would be advisable to cut trees with basal fire scars at the earliest opportunity following a fire.

On the assumption that firm red stain will yield a high recovery of pulp, there appears to be no urgency for reasons of decay to cut fire-scarred trees for pulpwood, at least up to 30 years following a fire. However, since we know nothing of the characteristics of S. pini and to avoid such factors as increased bleaching costs, the earliest possible utilization of trees with basal fire scars appears to be the most reasonable approach to the management of these stands.

To summarize, heart rot and management considerations of lodgepole pine are based on specific conditions that are somewhat unique to this region. Complicating this subject is the fact that most of the decay in our present stands is firm incipient and caused largely by one fungus, Stereum pini, whose characteristics are virtually unknown. The best we can do is to hope that it acts in wood similarly to Fomes pini. However, until investigations are completed to determine these facts for Stereum pini, the situation will remain confounded.

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LOGGING DAMAGE IN SPRUCE-BALSAM STANDS IN BRITISH COLUMBIA

A. K. Parker

At the request of the British Columbia Forest Service a logging damage study was undertaken in the Prince George region of B. C. during the period 1955-1957. Prince George is the approximate geographical and spruce-logging center of the Province, where tractor logging and individual tree marking of crown timber sales have been in general practice for less than a decade. Attempts to leave potentially valuable residual stands have made it necessary for forest managers in the region to know how much damage may be tolerated during the initial cut. The present study was undertaken to determine some of the factors influencing the infection of scars by decay fungi, and to determine the amount of decay associated with scars of different types and ages on residual spruce (*Picea glauca* (Moench) Voss var *albertiana* (S. Brown) Sarg.) and balsam (*Abies lasiocarpa* (Hook.) Nutt.).

Methods. Residual stands were selected for sampling on the basis of time since the initial cut, site and composition. Sampling was confined to that part of spruce-balsam stands in devil's club, Aralia-Dryopteris (sarsaparilla - oak fern) and moss associations. All stands were within a 50-mile radius of Prince George. Of the six stands sampled, four had been partially cut 5 years prior to examination, one stand had scars averaging 15 (14-16) years of age, and the remaining stand had scars averaging 31 (24-37) years of age.

All trees having scars to be examined were felled and dissected into 16-ft. logs. The upper surfaces of all lateral roots were uncovered for a distance of 3 feet from the base of the tree. Height, age, diameter at the time of examination, and diameter at the time the stand was partially cut were recorded for all trees. Cubic foot volumes, from a stump height of 1 foot to the top of the tree were computed by Smalian's formula for all trees examined in the stands having an average scar age of 15 and 31 years.

With the exception of broken tops, all scars were classified as to their position on the tree, size and depth. Four positions were recognized: roots, ground contact, butt and upper bole. Scars occurring entirely below the ground line were classed as root scars. Scars in contact with the soil, other than root scars, were classed as ground-contact scars. Scars with their lower edge occurring between ground level and d.b.h. were classed as butt scars. Scars occurring entirely above d.b.h. were classed as upper-bole scars. Each scar was placed in one of three size classes: scars having a surface area up to 36 square inches were classed as size 1; scars having a surface area between 37 and 144 square inches were classed as size 2; and scars having a surface area greater than 144 square inches were classed as size 3. Each scar was further classified as to depth. If the bark had been removed without obvious damage to the sapwood the scar was classed as having a depth b, and if the sapwood had been gouged the scar was classed as having a depth s.

Each scar was examined for the presence of decay by sectioning with an axe or power saw. Scars were classed as healthy or infected and cubic foot volumes of the associated decay were computed by Smalian's formula. Scars having less than 0.1 cubic foot of associated decay were classed as being infected but the volumes were not used in compiling data for this study. A sample of decay associated with each 5- and 31-year-old infected scar and from 345 of the 961 15-year-old scars was shipped to the laboratory for isolation and cultural identification of the decay organism.

The relation of locality to scar infection. Trees in 4 residual spruce-balsam stands, which had been partially cut 5 years prior to the study, were sampled for the level of infection in butt scars of size 2 and depth s. The stands were located near Summit Lake 30 miles north of Prince George, Stone Creek 25 miles south of Prince George, Willow River 20 miles east of Prince George, and at Upper Fraser 50 miles east of Prince George. All the spruce trees sampled were in the 12-16 -inch diameter class and all balsam trees were in the 4-6 diameter class. All spruce and balsam were located on the Aralia-Dryopteris (A-D) site except those in the stand at Upper Fraser. Because of the scarcity of trees on an A-D site in the stand at Upper Fraser all sample trees were selected from the devil's club (D-C) site. As a considerable number of upper-bole scars of size 1 and depth b were found on the trees selected for sampling the level of infection is reported for these scars as well as for the butt scars (table 1).

Infection levels in the butt scars on spruce were 92 percent at Summit Lake, 97 percent at Stone Creek, 68 percent at Willow River and 65 percent at Upper Fraser. Differences between infection levels in butt scars at Summit Lake and Stone Creek and between infection levels in butt scars at Willow River and Upper Fraser were not statistically significant. However, the differences between infection levels of butt scars at Summit Lake and Stone Creek as compared to those at Willow River and Upper Fraser were highly significant (P less than 0.005).

Table 1. -- The Relation of Infection of Butt and Upper-bole Scars on Spruce to Locality

Locality	Diameter class	Ave. age	Site	No. of trees	Scar types			
					Butt 2-s		Upper bole 1-b	
					No.	Percent infected	No.	Percent infected
Summit Lake	12-16	172	A-D	41	50	92	11	36
Stone Creek	12-16	113	A-D	34	37	97	19	21
Willow River	12-16	119	A-D	39	41	68	62	10
Upper Fraser	12-16	152	D-C	33	34	65	11	9

Infection levels in the upper-bole scars on spruce were 36 percent at Summit Lake, 21 percent at Stone Creek, 10 percent at Willow River and 9 percent at Upper Fraser. Differences between infection levels in upper-bole scars at Summit Lake and Stone Creek and between infection levels in upper-bole scars at Willow River and Upper Fraser were not statistically significant. As for the sample of butt scars, the differences between infection levels of upper-bole scars at Summit Lake and Stone Creek as compared to those at Willow River and Upper Fraser were statistically significant (P less than 0.05).

Infection levels in the butt scars on balsam were 93 percent at Summit Lake, 98 percent at Stone Creek, 93 percent at Willow River and 100 percent at Upper Fraser (table 2). Infection levels in the upper-bole scars of balsam were 45 percent at Summit Lake, 49 percent at Stone Creek, 67 percent at Willow River and 55 percent at Upper Fraser. There was no significant difference between infection levels at the four localities.

Table 2. -- The Relation of Infection of Butt and Upper-bole Scars on Balsam to Locality

Locality	Diameter class	Ave. age	Site	No. of trees	Scar types			
					Butt 2-s		Upper bole 1-b	
					No.	Percent infected	No.	Percent infected
Summit Lake	4-6	86	A-D	40	46	93	33	45
Stone Creek	4-6	97	A-D	37	43	98	49	49
Willow River	4-6	89	A-D	40	44	93	33	67
Upper Fraser	4-6	93	D-C	40	45	100	42	55

The higher level of infection in butt and upper-bole scars on spruce in stands north and south of Prince George than in stands east of Prince George illustrates the difficulty in relating the results obtained from one stand of a region to another stand of the same region. Although differences in the level of infection between stands probably become less with time, the stand with a higher level of infection soon after logging will most likely have significantly more decay associated with scars at the time of the next cutting cycle, because of an earlier beginning of decay activity. Reasons for the differences in infection level of scars between stands of the same general region are not clear but perhaps they are connected with the ecology of the decay organisms invading scars. Stereum sanguinolentum was the organism mainly responsible for infection of scars on spruce in all the stands studied. That moisture may be the ecological factor responsible for causing the difference in infection levels between the two areas, through an influence on the spread and development of S. sanguinolentum, is indicated by weather records for recent years showing an average of 12 inches less rainfall at Prince George than 40 miles east at Aleza Lake. S. chailletii and S. sanguinolentum were the organisms mainly responsible for infection of scars on balsam in all the stands studied. The ecological factors that encourage S. sanguinolentum in one stand may discourage S. chailletii and the reverse may be true in another stand so that infection levels in scars on balsam remain essentially the same in all stands. Unfortunately, it was not possible to obtain precise data on the relative abundance of the two fungi in each of the stands studied because less than half of the culture samples taken from infected scars yielded a decay-producing organism when cultured.

The relation of tree diameter to scar infection. A stand near Stone Creek was sampled to determine the relation of scar infection in spruce to tree diameter

and a stand near Summit Lake was sampled to determine the relationship in balsam. Both stands had been partially cut five years prior to sampling. All trees selected for sampling were on an A-D site and were in the 4-6 -inch or 12-16 -inch diameter class. All trees had at least one butt scar of size 2 and depth s. Because the selected trees had a number of root and ground contact scars infection levels for these scars are also reported (table 3).

Infection levels in the butt scars on spruce were 76 percent for trees in the 4-6 - inch diameter class and 97 percent for trees in the 12-16 -inch diameter class. Infection levels in all the root and ground-contact scars on the selected spruce were 82 percent for trees in the 4-6 -inch diameter class and 93 percent on trees in the 12-16 -inch diameter class. The slightly higher infection levels in scars on trees of the 12-16 -inch diameter class than in those on trees of the 4-6 -inch diameter class for root and ground-contact scars were not statistically significant. However, the 21 percent higher level of infection in butt scars on the larger diameter class trees was significant (P less than 0.01).

Table 3. -- The Relation of Scar Infection in Spruce and Balsam to Tree Diameter

Species	Diam. class (in.)	Ave. age	Site	No. of trees	Scar types			
					Root and ground contact		Butt 2-s	
					No.	Percent infected	No.	Percent infected
Spruce								
(Stone Creek)	4- 6	100	A-D	40	11	82	45	76
	12-16	113	A-D	34	29	93	37	97
Balsam								
(Summit Lake)	4- 6	86	A-D	40	6	100	46	93
	12-16	133	A-D	40	9	100	44	100

Infection levels in the butt scars on balsam were 93 percent for trees in the 4-6 -inch diameter class and 100 percent for trees in the 12-16 -inch diameter class. Infection levels in the root and ground-contact scars on the selected balsam were 100 percent for the 4-6 -inch and the 12-16 -inch diameter classes. The 7 percent higher level of infection in butt scars on the larger diameter class trees was only significant to the 5-10 percent level (P less than 0.1).

The lower level of infection in butt scars of size 2 and depth s on spruce in the 4-6 -inch diameter class than on spruce in the 12-16 -inch diameter class is difficult to explain on the basis of our present knowledge. The trees sampled in the two diameter classes were approximately the same age. Perhaps slower

growing trees are more resistant to invasion by fungi than faster growing trees, or perhaps the microclimate near trees of small diameter was sufficiently different from the microclimate near the trees of large diameter to affect infection levels in scars. However, the factors responsible for influencing infection levels in the butt scars on spruce in the two diameter classes were not present or not sufficient to cause differences in infection levels in root and ground-contact scars on spruce and balsam, or in butt scars of size 2 and depths on balsam.

The relation of site to scar infection. A stand near Summit Lake which had been partially cut 5 years prior to sampling was selected for determining the relation of scar infection to site. All trees selected for sampling were located on either an A-D site or a D-C site and each had at least one butt scar of size 2 and depths. All spruce trees sampled were in the 12-16 -inch diameter class and all balsam were in the 4-6 -inch diameter class. There was no significant difference between the results obtained for levels of infection in the scars on spruce and balsam on the A-D site and the results obtained on the D-C site (table 4). The factors governing site differences did not appear to influence infection levels in the scars sampled.

Table 4. -- The Relation of Scar Infection in Spruce and Balsam to Site at Summit Lake

Species	Diam. class (in.)	Ave. age	Site	No. of trees	Scar types			
					Root and ground contact		Butt 2-s	
					No.	Percent infected	No.	Percent infected
Spruce	12-16	172	A-D	41	24	88	50	92
	12-16	166	D-C	39	16	88	43	88
Balsam	4- 6	86	A-D	40	6	100	46	93
	4- 6	88	D-C	31	6	100	31	100

Infection of 5- and 15-year-old scars on spruce and balsam. Three stands east of Prince George were selected for comparison of infection levels in scars of two different ages. Stands near Willow River and Upper Fraser had been partially cut five years prior to sampling and were the same stands sampled previously for the level of infection in butt scars. A stand near Giscome had been partially cut 14 - 16 years prior to sampling and was located approximately 10 miles from the stand at Willow River. In the stands at Willow River and Giscome trees for analysis were selected initially on the basis that they had at least one scar, were of 4 inches d.b.h. or larger, and were on an A-D, D-C or C-M (Moss) site.

Sampling for any one scar was discontinued once an apparently adequate sample had been obtained. The stand at Upper Fraser was not sampled beyond that necessary to obtain data on the level of infection in butt scars but data were recorded on all scars occurring on the trees.

Spruce: Infection levels in scars on 121 spruce in the stands near Willow River and Upper Fraser, and on 124 spruce in the stand near Giscome are presented in tables 5 and 6. Spruce in the Willow River and Upper Fraser stands had a total of 374 scars, an average d.b.h. of 12.6 inches, and an average age of 126 years. Spruce in the Giscome stand had a total of 516 scars, an average d.b.h. of 12.1 inches, and an average age of 150 years.

Table 5. -- Percent Infection by Decay Organisms of 5-year-old Scars on Spruce in Stands East of Prince George

Position	Scars		Location of stands			
	Size	Depth	Willow River		Upper Fraser	
			No. of scars	Percentage of scars infected	No. of scars	Percentage of scars infected
Roots	1	b & s	7	100	6	66
	2	b & s	3	67	7	100
	3	b & s	12	100	9	100
Ground-contact	1	b & s	1	100	-	50
	2	b & s	5	60	1	-
	3	b & s	28	93	6	100
Butt	1	b	17	24	7	14
		s	2	50	3	-
	2	b	2	50	1	100
		s	46	70	34	65
	3	b	5	60	-	-
		s	27	67	1	100
Upper-bole	1	b	83	8	11	9
		s	10	20	1	100
	2	b	9	22	-	-
		s	11	36	1	-
	3	b	4	25	-	-
		s	7	86	-	-

Table 6. -- Percent Infection by Decay Organisms of 15-year-old Scars on Spruce in a Stand (Giscome) East of Prince George

Position	Scars		Age of scars (years)	
	Size	Depth	15	
			No. of scars	Percentage of scars infected
Roots	1	b & s	34	97
	2	b & s	16	100
	3	b & s	21	100
Ground contact	1	b & s	9	100
	2	b & s	23	100
	3	b & s	13	100
Butt	1	b	49	49
		s	22	45
	2	b	11	73
		s	39	90
	3	b	5	100
		s	25	100
Upper bole	1	b	66	6
		s	48	19
	2	b	44	57
		s	34	59
	3	b	10	90
		s	18	94

In general, the infection levels decreased from the lower part of the tree to the upper bole in 5- and 15-year-old spruce scars with an area less than 144 square inches. Apparently conditions near the ground are more suitable than higher up the tree for infection of scars by the fungi causing decay. However, nearly 100 percent of the scars in the four positions with an area greater than 144 square inches were infected. Somewhere between scar areas of 144 square inches and the larger scar areas encountered in this study the positions of the scars on trees no longer had an influence on infection levels. The effect of scar size on infection levels was more evident in upper-bole scars on spruce than in scars located in the other positions. The difference in infection levels between depth b upper-bole scars of size 1 and size 3 was 84 percent, compared to 55 percent in depth s butt scars in the same size categories. Scar size showed little effect on infection levels at 15 years in root and ground-contact scars. Larger butt and upper-bole scars are more exposed to spores of decay-causing fungi and are more likely to have favorable infection courts for growth of the fungi than smaller scars. Root and ground-contact scars are not dependent on airborne spores of fungi for infection and soil in contact with scars appears to create favorable infection courts for a large number of fungi. There was a higher level of infection in upper-bole scars of size 1 at 5 years

than at 15 years. Conditions may have been more favorable for development of, and infection by, decay-causing fungi during the years following logging of the stand with 5-year-old scars than during the period immediately following logging of the stand with 15-year-old scars. As healing of most small scars in the upper bole occurred in less than 15 years the chances for decay-causing fungi to enter the 15-year-old scars during the last 10 years was considerably reduced with the result that a higher level of infection was obtained for the 5-year-old scars than for the 15-year-old scars. In 15-year-old scars on spruce the depth of scarring appeared to have influenced appreciably the infection of butt scars of size 2 and upper-bole scars of size 1, but not the infection of the other scar types. A 17 percent higher level of infection occurred in the butt scars of depth s than of depth b, and a 13 percent higher level of infection occurred in upper-bole scars of depth s than of depth b. The choice of definitions for scars of depth b and s probably influenced the results obtained for infection levels in butt and upper-bole scars of any one size. Scars of depth s included those gouged deeply by bulldozer blades as well as those with only slight scratching of the exposed sapwood surface. If the butt scars of size 1 and depth s sampled had only slight scratching of the exposed sapwood surface the infection level obtained would probably be very little different from the infection level obtained for butt scars of size 1 and depth b.

Balsam: Infection levels in scars on 114 balsam in the stands near Willow River and Upper Fraser, and on 118 balsam in the stand near Giscome are presented in tables 7 and 8. Balsam in the Willow River and Upper Fraser stands had a total of 408 scars, an average d.b.h. of 7.1 inches and an average age of 98 years. Balsam in the Giscome stand had a total of 451 scars, an average d.b.h. of 11.6 inches, and an average age of 137 years.

Infection levels obtained for scars on balsam showed that after 5 years very little increase in infection is likely to occur. Scars on balsam appeared more susceptible to infection than scars on spruce. All infection levels less than 100 percent for balsam scars were greater than infection levels for the corresponding scars on spruce. The trends in infection levels noted for the position, size and depth of spruce scars apply to balsam scars but they are not so pronounced.

Table 7. -- Percent Infection by Decay Organisms of 5-year-old Scars on Balsam in Stands East of Prince George

Position	Scars		Location of stands			
	Size	Depth	Willow River		Upper Fraser	
			No. of scars	Percentage of scars infected	No. of scars	Percentage of scars infected
Roots	1	b & s	13	69	11	100
	2	b & s	1	100	5	100
	3	b & s	3	100	5	100
Ground contact	1	b & s	4	100	1	100
	2	b & s	2	100	3	100
	3	b & s	11	100	3	100
Butt	1	b	20	75	15	73
		s	11	100	6	100
	2	b	1	100	3	100
		s	46	93	45	100
	3	b	4	75	-	-
		s	24	100	2	100
Upper bole	1	b	44	73	42	55
		s	7	100	19	84
	2	b	16	88	1	-
		s	4	100	8	88
	3	b	2	100	-	-
		s	7	100	1	100

Table 8. -- Percent Infection by Decay Organisms of 15-year-old Scars on Balsam in a Stand (Giscome) East of Prince George

Position	Scars		Age of scars (years)	
	Size	Depth	No. of scars	Percentage of scars infected
Roots	1	b & s	22	100
	2	b & s	6	100
	3	b & s	11	100
Ground contact	1	b & s	5	100
	2	b & s	13	100
	3	b & s	27	100
Butt	1	b	20	50
		s	26	92
	2	b	15	100
		s	47	100
	3	b	6	100
		s	33	100
Upper bole	1	b	51	59
		s	46	74
	2	b	30	90
		s	32	91
	3	b	9	100
		s	21	100

Decay associated with scars on spruce and balsam. The stands east of Prince George were selected for determining the amount of decay associated with scars of different types. One stand was near Giscome (mentioned in the previous section on infection levels) and had scars averaging 15 years of age. The second stand was near Aleza Lake and had scars averaging 31 years of age. Spruce having butt scars and balsam having butt and large upper-bole scars were selected for sampling in the stand near Aleza Lake. The percent of the average tree volume with decay when scars of different types occur is presented in tables 9 and 10. The average amount of decay for each scar type was determined by dividing the amount of decay associated with infected scars by the total number of scars. Percent of decay for each scar type was then determined by dividing the average decay by the average gross volume of the trees sampled and multiplying by 100. Decay associated with the 5-year-old scars of the other stands examined was in most cases less than 0.1 cubic feet for each scar and was not recorded.

The decay associated with 516 scars on 124 spruce and 451 scars on 118 balsam in the stand near Giscome and the decay in 85 scars on 43 spruce and 134 scars on 52 balsam in the stand near Aleza Lake was determined. Spruce in the Giscome stand had an average gross volume of 22.5 cubic feet per tree, an average d.b.h. of 12.1 inches and an average age of 150 years. Balsam in the Giscome stand had an average gross volume of 19.8 cubic feet per tree, an average d.b.h. of 11.6 inches, and an average age of 137 years. Spruce in the Aleza Lake stand had an average gross volume of 28.6 cubic feet per tree, an average d.b.h. of 14.5 inches, and an average age of 132 years. Balsam in the Aleza Lake stand had an average gross volume of 18.0 cubic feet per tree, an average d.b.h. of 11.2 inches and an average age of 121 years.

Table 9. -- Decay Associated with 15- and 31-year-old Scars on Spruce in Stands East of Prince George

Age and type of scar				Decay associated with scars				
Age (years)	Position	Size	Depth	Total no. of scars	Decay (cu. ft.)	Ave. decay per scar (cu. ft.)	Percentage of volume decay ^{1/}	
15	Roots	1	b	22	1.7	0.1	0.4	
			s	12	2.1	0.2	0.9	
		2	b	7	1.8	0.3	1.3	
			s	9	2.9	0.3	1.3	
		3	b	2	0.4	0.2	0.9	
			s	19	10.2	0.5	2.2	
	Ground contact	1	b	6	2.0	0.3	1.3	
			s	3	1.0	0.3	1.3	
		2	b	15	4.3	0.3	1.3	
			s	8	1.8	0.2	0.9	
		3	b	2	1.2	0.6	2.7	
			s	11	15.2	1.4	6.2	
	Butt	1	b	49	3.5	0.1	0.4	
			s	22	0.5	-	-	
		2	b	11	2.3	0.2	0.9	
			s	39	13.5	0.4	1.8	
		3	b	5	2.5	0.5	2.2	
			s	25	16.0	0.6	2.7	
		Upper bole	1	b	66	3.0	-	-
				s	48	4.1	0.1	0.4
2			b	44	4.8	0.1	0.4	
			s	34	5.5	0.2	0.9	
3	b	10	2.2	0.2	0.9			
	s	18	21.3	1.2	5.3			
31	Butt	2	s	26	15.0	0.6	2.1	
		3	s	12	22.7	1.9	6.6	
	Upper bole	1	b	18	3.1	0.2	0.7	

^{1/} The average gross volume of the trees sampled was 22.5 cu. ft. in the stand near Giscome with 15-year-old scars and 28.6 cu. ft. in the stand near Aleza Lake with 31-year-old scars.

Table 10. -- Decay Associated with 15- and 31-year-old Scars on Balsam in Stands East of Prince George

Age and type				Decay associated with scars			
Age (yrs.)	Position	Size	Depth	Total no. of scars	Decay (cu. ft.)	Ave. decay per scar (cu. ft.)	Percentage of tree volume decayed ^{1/}
15	Roots	1	b	10	0.1	-	-
			s	12	0.3	-	-
		2	b	2	-	-	-
			s	4	0.6	0.1	0.5
		3	b	-	-	-	-
			s	11	2.0	0.2	1.0
	Ground contact	1	b	2	-	-	-
			s	3	-	-	-
		2	b	4	0.2	0.1	0.5
			s	9	1.3	0.1	0.5
		3	b	1	0.7	0.7	3.5
			s	26	19.5	0.8	4.0
	Butt	1	b	20	0.2	-	-
			s	26	1.3	0.1	0.5
		2	b	15	2.6	0.2	1.0
			s	47	12.5	0.3	1.5
		3	b	6	2.1	0.4	2.0
			s	33	19.7	0.6	3.0
	Upper bole	1	b	51	3.1	0.1	0.5
			s	46	2.5	0.1	0.5
		2	b	30	3.0	0.1	0.5
s			32	4.2	0.1	0.5	
3		b	9	4.3	0.5	2.5	
		s	21	22.0	1.0	5.1	
31	Butt	2	s	25	10.3	0.4	2.2
		3	s	15	19.9	1.3	7.2
	Upper bole	1	b	33	20.4	0.6	3.3
		1	s	10	1.5	0.2	1.1
		2	s	12	10.8	0.9	5.0
		3	s	9	15.5	1.7	9.4

^{1/} The average gross volume of the trees sampled was 19.8 cu. ft. in the stand near Giscome with 15-year-old scars and 18.0 cu. ft. in the stand near Aleza Lake with 31-year-old scars.

The percentage of a spruce or balsam tree affected by decay associated with a root or ground-contact scar was smaller than indicated by infection levels because the decay had to have reached stump height before being measured and recorded in this study. The same general trend in infection levels of butt and upper-bole scars with scar size and depth are noted in the percentages of decay. With the exception of ground-contact scars of sizes 1 and 2 on spruce, and upper-bole scars of sizes 1 and 2 on balsam, the smaller the scar the less associated decay. With the exception of butt scars of size 1 on spruce the more superficial a scar the less associated decay. The effect of scar size on percentage of decay associated with 15-year-old root and ground-contact scars was noted whereas the effect of scar size on infection levels for the same scars was not discernible, indicating that the larger areas of exposed sapwood allow decay to proceed at a faster rate than smaller areas. The percentage of a balsam tree affected by decay entering a root or ground-contact scar was generally less in 15 years than the percentage of a spruce tree affected by decay entering the same scars. The percentage of a tree affected by decay associated with 15-year-old butt and upper-bole scars was approximately the same for both balsam and spruce, in spite of the higher level of infection in balsam scars. The rate of development of decay in spruce is apparently greater than the rate in balsam. The difference in rates may be due to the different fungi-causing decay in the two hosts as well as a difference in the hosts themselves.

Loss of wood through decay was for most 15-year-old scars a rather small percentage of the total volume of a tree. However, in this study trees selected on the basis of having one scar were found to have an average of two more. Considering the amount of decay associated with a size 3 scar and two smaller scars of different types, the increase in decay associated with scars when a residual stand is left without cutting for longer than 15 years, and the amount of decay not associated with scars, the loss adds up to a much higher percentage of the total volume of a tree than indicated by the percent decay associated with a single scar. Another way of viewing losses is to consider the volume loss associated with the most valuable part of the tree--the lower log. As approximately one-half of the total volume of a spruce or balsam is contained in the lower 16 feet of the tree the values found for percent decay associated with root, ground-contact and butt scars are doubled when considering loss in only the lower log. Other factors requiring consideration by forest managers are the loss from windthrow of trees with scarred roots weakened by decay; the loss of vigorous growth and often considerable volume through tops being broken in the logging operation; and the increase with time in the danger of breakage at the site of larger scars, particularly in the upper bole, because of deep radial penetration of decay. In the Prince George region, greater values for percent decay are to be expected for scars on spruce in stands north and south of Prince George than were presented for stands east of Prince George.

Occurrence of fungi isolated from decays associated with scars on spruce and balsam. Culture samples were taken from the decayed portion of 732 infected scars occurring on spruce (table 11) and 1119 infected scars on balsam (table 12) in the 6 stands studied. Because only 57 percent of the decay samples from spruce and only 42 percent of the samples from balsam yielded basidiomycetes when cultured, little may be said with certainty of the decay fungi isolated in relation to scar types. The frequency of isolation of S. sanguinolentum from spruce scars and S. chailetii and S. sanguinolentum from balsam scars, however, leaves little doubt that these fungi are the most important invaders

of all scar types in the Prince George region. The most important root and butt rots encountered during decay studies on spruce and balsam in Alberta and British Columbia were found associated only rarely with scars in this study. S. sanguinolentum was the most frequently encountered trunk rot during decay studies on spruce and balsam but S. chailletii was encountered only rarely. The type of infection court created on different parts of a tree appears to determine to a considerable extent the decay fungi attacking the tree, and should be considered when comparing the results of a decay study in one region with the results obtained in other regions.

Table 11 -- Frequency of Occurrence of Fungi Isolated from Decays Associated with Scars on Spruce

	Type and number of scars					Total
	Root	Ground contact	Butt	Upper bole	Broken top	
Culture samples with decay						
No.	136	73	402	121	37	732
No. yielding basidiomycete fungi	65	40	229	69	16	419
Fungi ^{1/}						
<u>Stereum sanguinolentum</u> (Alb. & Schw. ex Fr.) Fr.	37	30	202	60	11	340
<u>Peniophora septentrionalis</u> Laurila	2	3	6	7	3	21
<u>Coniophora puteana</u> (Schum. ex Fr.) Karst.	8	2	1	-	-	11
<u>Fomes pinicola</u> (Sw. ex Fr.) Cooke	2	3	4	-	1	10
<u>Corticium galactinum</u> (Fr.) Burt	4	2	2	-	-	8

^{1/}

Includes only the 5 most frequently isolated basidiomycetes.

Table 12. -- Frequency of Occurrence of Fungi Isolated from
Decays Associated with Scars on Balsam

	Type and number of scars					Total
	Root	Ground contact	Butt	Upper bole	Broken top	
Culture samples with decay						
No.	63	60	544	452	57	1119
No. yielding basidiomycete fungi	11	20	249	165	21	466
Fungi ^{1/}						
<u>Stereum chailletii</u> Pers.	1	12	140	75	4	232
<u>Stereum sanguinolentum</u> (Alb. & Schw. ex Fr.) Fr.	5	5	76	73	13	172
<u>Corticium laeva</u> Pers.	-	-	13	2	-	15
<u>Armillaria mellea</u> Vahl ex Fr.	5	1	1	-	-	7
<u>Corticium galactinum</u> (Fr.) Burt	-	1	2	2	-	5

^{1/} Includes only the 5 most frequently isolated basidiomycetes

NEMATODES IN THE WESTERN WHITE PINE TYPE

W. R. Nickle and R. L. Gilbertson

This paper deals with a group of plant parasites which, although well known to be associated with diseases of many plants, have never been the subject of a paper before this conference. Nematodes are known to be among the most ubiquitous organisms on the face of the earth. Some are animal parasites. Many live in bodies of fresh water or in the ocean, and great numbers of them inhabit the soil. Most of the soil-inhabiting nematodes are free-living organisms that feed on dead organic material, bacteria, and other organisms including other nematodes. Many, however, are known to be parasitic on living plants and are considered to be the cause of a number of plant diseases.

The applied aspects of nematology have dealt almost entirely with diseases of agricultural crops, and little attention has been given to the role of nematodes in the soil environment of forest trees. Also, forest pathologists have tended to consider nematodes as being outside their sphere of professional interest. As a result, little is known of the significance of nematodes to forest pathology. That nematodes are injurious to forest nursery stock and some cultivated trees, including citrus trees and walnuts (Heald, 1926) has been established.

In the course of pole blight investigations over the past 10 years, researchers have found themselves face-to-face with a frustrating lack of basic information on the root environment of western white pine. The need for study of nematode populations has been recognized for some time, but attempts to have a nematologist study the pole blight problem have not been successful.

An examination of the literature concerning effects of nematode damage to plants seems to justify a study of these organisms in connection with the decline of white pine known as pole blight.

In a paper on nematodes affecting trees and shrubs, Sasser (1954) has this to say regarding plants parasitized by nematodes: "They are rarely killed outright. In general, parasitized plants slowly decline. Dieback, yellowing, wilting, and premature shedding of foliage are common symptoms of decline. Infected plants are often more susceptible to other soil-borne pathogens, as well as winter injury or drought."

In a review article on plant parasitic nematodes, Taylor (1953) states that "nematodes should always be considered as a possible cause of plant diseases when root systems are galled, shortened, or reduced by rotting; when the stems are shortened or thickened and the leaves do not grow normally, and some other abnormal growth is noted". Of course, the symptom complex described in these references could result from other factors, but it is a fairly good description of the condition of pole-blighted white pines. In this same review, Taylor points out that "all plant parasitic nematodes are more or less specialized, attacking some plants freely and others not at all". This specificity is interesting in light of the fact that associated species in the white pine type have not been affected by pole blight.

In discussing the effects of the "stubby root" nematodes of the genus Trichodorus (which we have found to be widely distributed in the white pine type) Taylor states, "The feeding causes the root tip to stop growing and turn brown. Parts of the root may then die, probably because of attacks by secondary invaders. The final result is a reduced root system with many short root stubs". This condition is similar to that found to exist in the case of pole blight by Copeland and Leaphart (1955) and McMinn (1955).

Taylor also points out that "Nematodes are seldom evenly distributed in the soil, so the growth of plants is uneven and patches of stunted plants may appear here and there. Heavily infected plants die prematurely, because of rotting of the roots, while clean or lightly infected plants are still growing normally". This is reminiscent of the distribution pattern observed in pole blight stands.

Studies on the distribution and amounts of mineral nutrients in pole blight trees have revealed a deficiency of N, Ca, Mg, Mn and B, and a surplus of K and P. Chitwood (1952) reports a deficiency of all mineral nutrients except K in leaves of peach trees infected by nematodes regardless of specific nematode treatment or seedling variety. That is to say, distribution patterns similar to those observed in pole blight trees occur in some nematode-infected plants.

The preceding brief comparative review of the symptomatology of nematode-infected plants and that observed in pole-blighted white pines is not intended to imply that nematodes are a probable cause of the disease. Undoubtedly, just as good a case could be presented for a number of other biotic and abiotic factors. However, it does appear to provide ample justification for the investigation of nematodes in relation to pole blight in light of our present virtual lack of information concerning these organisms in the white pine type. From the standpoint of basic research, the information gained should be of considerable value, regardless of the relationship to pole blight.

The first objective of this investigation was to determine the identity and distribution of nematodes present in pole-blighted and healthy white pine stands in northern Idaho, with special emphasis on plant parasites. The remainder of this paper presents the information we have accumulated to date in line with this objective.

Methods. Fourteen pole-blighted stands, 5 healthy stands in the pole blight range, and 6 healthy stands out of the pole blight range were selected as sampling locations. A soil auger was used to collect the soil samples, which were taken to the 2-foot level. Soil samples from the 1- and 2-foot levels were kept in separate plastic bags, and each stand was sampled at 5 locations. The soil was brought to the laboratory and the nematodes were extracted immediately. The Baermann funnel technique, which requires that nematodes be living for their extraction to be successful, was used. Immediate extraction was essential to isolate the obligate root parasites before they perished. Extracted nemas were observed in a Syracuse watch glass under a binocular microscope and representative specimens were removed with a fine needle and mounted semi-permanently in lacto-phenol with cotton blue. After being ringed with colorless nail polish, the slides were studied under a compound microscope and nematodes not readily identified were sent to specialists. The plant nematologists who aided us with identifications and advisory assistance were:

Dr. M. W. Allen, Dept. of Pl. Nematology, University of California, Berkeley, California.

Dr. A. L. Taylor, Nematology Section, U.S.D.A., Beltsville, Maryland.

Mr. Edsil Jorgenson, Nematologist, A. R. S., 477 Federal Building, Salt Lake City, Utah.

Mr. Gerald Thorne, formerly Nematologist, A. R. S., 477 Federal Building, Salt Lake City, Utah.

Dr. B. G. Chitwood, Chief Nematologist, State Plant Board, Gainesville, Florida.

Dr. G. Steiner, Nematologist, University of Puerto Rico, Rio Piedras, Puerto Rico.

Dr. D. G. Raski, Assoc. Nematologist, Dept. of Pl. Nematology, University of California at Davis, California.

Dr. J. R. Christie, Nematologist, University of Florida, Gainesville, Florida.

Discussion of nematode genera found. In all, approximately 21 genera of nematodes were found to be represented in the samples. These genera and their distribution over the area sampled are shown in figure 1. Listed first are 8 genera that include well-known root parasites. Next are listed 9 genera which include nematodes with more omnivorous or unknown feeding habits. The final group of 5 genera include those considered to be free-living nematodes that feed on dead organic material or other microorganisms. Some nematodes as yet unidentified were found in all areas. Specific identifications of some of the nematodes found have not been possible. Consequently, a generic grouping will be used for purposes of discussion.

Trichodorus includes migratory ectoparasites commonly known as "the stubby root nematodes". Allen (1957) reworked this genus and added 10 new species to the 2 existing at that time. One of these new species, T. elegans was named from specimens found in soil from a pole blight area on Nickleplate Mountain in the Kaniksu National Forest. Although this genus contains species that are known to have a very wide host range, it is interesting to note that 8 of the 12 species have been found near roots of trees. Four of these 8 were found near pine roots. T. elegans was found in all of the 14 pole blight areas sampled. However, it was also found at Rosebud Cr. and Pierce R. S., both considered to be out of the range of pole blight. The organisms in this genus feed on many rootlets in a lifetime, injecting enzymes into the rootlets which cause them to cease growing. Deterioration, possibly as a result of secondary invaders, then occurs, and a much reduced root system results. Results of greenhouse tests indicate that western white pine is a host of T. elegans.

The genus Meloidodera was described by Chitwood (1956) and presently includes but one species, Meloidodera floridensis. The pine cystoid nema, as Chitwood calls it, was found parasitic on slash pine seedlings in a Florida nursery. Chitwood said that the pine seedlings were stunted and unthrifty and it appeared to him that the damage to the seedlings was proportional to the degree of nematode infection. Specimens of larvae very similar to those of M. floridensis were found by Allen in soil from a pole blight area in the Fourth of July Canyon, and adult females apparently of this organism were observed embedded in western white pine rootlets. This organism is currently being studied by Allen and Chitwood who are considering it as a possible new genus. The larva of this organism probably burrows into the new rootlet and lies in the cortex with its anterior end facing away from the root tip. If it is to be a female, it continues feeding and expands until it ruptures the outer cortex and is visible as a small whitish yellow cyst. No root knots or swellings are present on the roots. This organism was found as an adult female only from the latter part of August to the latter part of September in the Fourth of July Canyon pole blight area.

Criconemoides, the genus of ring nematodes, was represented in three pole blight areas. Several members of this genus are considered important associates with plant diseases. Large numbers of Criconemoides simili have been associated with a peach tree decline in North Carolina (Chitwood, 1949). Criconemoides rusticum has been found associated with the littleleaf disease of shortleaf pine in the South (Jackson, 1948). However, the relationship of these organisms to the diseases mentioned is not known. Many other species of this genus have been found near trees.

The genus Rotylenchus has a wide host range and is considered wholly or intermittently parasitic on plant roots. The members of this genus are migratory semi-endoparasites. Nematodes belonging to this genus were found in three pole blight areas and one healthy area.

Criconema, the spine nematode, was represented in two pole blight areas. The food habits of this genus are generally unknown, but some are known to puncture and feed on roots of fig and citrus trees (Chitwood, 1957).

Xiphinema americana, one of the "dagger nematodes" was found in a white pine plantation at the University of Idaho arboretum. It is a rather large form with a powerful stylet. This species is known to be parasitic on some plants. It was not found in natural stands of white pine.

Specimens of a nematode belonging to the genus Tylenchorhynchus were found by Thorne in soil from a pole blight area at Fernan Saddle. Members of this genus are probably intermittent feeders on plant roots.

Tylencholaimus was found in two pole blight areas. The food habits of members of this genus are unknown. One specimen was identified by Jorgenson as Tylencholaimus stecki.

Tylenchus was represented in several pole blight areas and also in several healthy stands. Allen states in correspondence that no member of this genus has been proven pathogenic to higher plants although they do belong to a family that contains several well-known pathogenic species. He also states that species of Tylenchus are very cosmopolitan in distribution and that they are present in nearly all types of soil.

Triplonchium and Diptherophora are two very similar genera. Both genera were represented in samples from several pole blight areas. The food habits of these organisms are unknown. One specimen of Diptherophora was identified as D. obesus by Jorgenson.

Aphelenchoide parietinus was found in one pole blight area. This species is not considered to be a parasite of higher plants.

An unidentified species of Axonchium was found by Thorne in soil from one pole blight area. The food habits of members of this genus are unknown.

Species of Dorylaimus were found in nearly every sample. One was identified as D. carteri. The genus is cosmopolitan and there is little evidence showing a pathogenic relationship of this genus with higher plants.

Dorylaimellus was represented in samples from one pole blight area. Again, the food habits of these nematodes are unknown.

Pungentus microdentatus was found in one pole blight area. The food habits of this species, as well as the other members of the genus, are not definitely known.

Monochus is a genus of carnivorous nematodes represented in almost every sample. A whole nematode was found in the gut of one of these organisms. Several subgenera and species are present in the western white pine type. The members of this genus feed on protozoa, nematodes, rotifers, and other small organisms.

The genus Plectus was represented quite often in the samples from both pole blight and healthy areas. The food habits are uncertain, but they probably feed on bacteria and minute organic particles. Several species were observed. One species was identified by the Beltsville laboratory as P. granulosis.

Nematodes belonging to the genus Prismatolaimus were found in four areas. The food habits of this genus are unknown.

Cephalobus was represented in two healthy and two pole blight areas. Members of this genus are probably saprophagous or microbivorous in habit and are widely distributed and common organisms.

Acrobeloides includes nematodes that are mainly soil inhabitants associated with plant roots or decaying plant tissues. They are found in practically all samples. Allen identified A. butschlii, which is considered to be a bacteria feeder.

In summary, approximately twenty-one genera of nematodes have been found in soil samples taken throughout the white pine type in northern Idaho. Among these are plant parasitic nematodes capable of causing a deterioration of fine rootlets such as has been demonstrated to occur as an early stage in the decline of western white pine trees known as pole blight. Circumstantial evidence indicates that Trichodorus elegans is parasitic on roots of western white pine. Unidentified females of the genus Meloidodera or a closely related genus have been found embedded in white pine roots. Other

genera, including Criconemoides, Criconema, Rotylenchus, and Tylenchorynchus, have possible pathogenic significance. Experimental work will be necessary to determine if a relationship exists between the nematodes found and pole blight of western white pine.

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Moderator's summary

Leaphart.--I believe that root pathogens and their ecology, specifically, the reasons for their presence and damage, are some of the more important unknowns in our general knowledge of forest pathology. The reasons for this are obvious to most of you. To quote Garrett, " 'Out of sight, out of mind' is an adage applicable to the roots of plants, though it is only fair to add that technical difficulties of observations have contributed to this comparative neglect of the root system. Our now greater familiarity with the difficulties of the root-disease investigation has not, however, bred contempt for them; on the contrary, a closer inspection has somewhat increased our respect for the obstacles to be surmounted."

Admitting that the study of root pathogens has certain inherent difficulties, we are, nevertheless, faced with many problems that require attention today. How we go about such studies and what aspects are involved to demonstrate the true picture of host-parasite relationships are the present worries of many of us now working or proposing work in this field.

The following well-known root pathogens were discussed:

Leptographium

Wagner.--Two forms of a root-inhabiting pathogenic Leptographium have been found in California; one affecting ponderosa and Jeffrey pines in several locations in northeastern California and the other attacking singleleaf pinyon in one area on the San Bernardino National Forest in southern California. This form has also been found by J. L. Mielke in pinyon pine (P. edulis) in Mesa Verde National Park and at one other location in western Colorado. The pinyon form appears to be more aggressive and more easily isolated than the ponderosa-Jeffrey form. Several attempts during the last two seasons to obtain a fresh isolate from the latter form have been unsuccessful.

It is not known how new centers become established but carriage by insects is suspected. From an initially infected tree the fungus spreads by root contact to adjacent root systems. Root grafts are not necessary for the transfer. In one case in pinyon pine where spread was followed from a single tree that had died from the disease prior to 1942 the fungus had invaded the roots and killed 36 additional trees through 1950. Escapes within the affected area were mostly small trees with limited root spread. Several additional trees within the area of infection were killed by Ips beetles that had built up in trees primarily attacked by Leptographium and had then invaded adjoining trees not showing the fungus at the base.

In natural infections the wood of the entire cross section of the smaller roots is invaded and the cambium is killed as the fungus progresses. Freshly invaded root wood appears blackish but turns to a brownish color as the moisture content of the dead wood decreases. After the root crown is reached the fungus extends upward in streaks in the outer sapwood of the tree butt. Dark resinous streaks often extend beyond the fungus limits.

In infection tests in which the fungus growing on wood splinters was inserted into root wounds on young forest trees, pathogenic lesions were

produced but no typical invasion of the root system by the fungus occurred. Typical infections developed only when blocks of green pine sapwood overgrown by the fungus were buried in contact with unwounded roots. No infection was obtained from the pinyon form of the fungus in contact with ponderosa and Jeffrey pine roots.

From a preliminary examination, the fungus appears to be very similar to one isolated by Leaphart from an eastern white pine plantation in Montana, where it was progressively spreading and killing trees as described by him at the Spokane Conference. Since Leptographium is a form genus, it can be expected to include a number of forms, some probably unrelated and showing no evidences of pathogenicity.

Fomes annosus

Wagener.--In California this fungus is common as a root and butt rot of firs and can occasionally be found killing smaller trees in forests west of the Sierra Nevada summit, but as a killer of ponderosa and Jeffrey pines of all ages its activity is chiefly confined to northeastern and southern California and to forests east of the Sierra Nevada summit. These are areas of relatively low average annual precipitation, a climate approaching the continental type and soils that are quite dry during most of the year but that in wet seasons may become saturated during the snow-melt period. Most of the mortality occurs on relatively level ground or near the base of local slopes. Killing of reproduction is often centered around stumps of trees logged from 5 to 10 years previously, but around older centers large pines may be killed. Most infection is through contact of healthy with infected roots. Where a zone of killing centers around a stump there often had been no evidence of the presence of Fomes annosus at the time the tree was cut, suggesting that infection of the stump or root system may have occurred following cutting. In England, Rishbeth found that the infection of stumps by spores following cutting was very common, but in east-side pine in California such infection is highly unlikely since sporophores are rare and when they are produced they are usually formed under a thick layer of needles and duff. A more likely source of establishment of the fungus in stumps is through the agency of insects such as the red turpentine beetle that characteristically colonize stumps.

There must be some ecological basis for the relative prevalence of pine mortality from F. annosus in east-side forests as compared with those on the west side of the Sierra Nevada and in the coast ranges of California. One basis that suggests itself is the effect of the temporary saturation of these normally rather dry soils during the snow-melt period in the spring. Some years ago Hopffgarten, in a survey of the F. annosus problem in Europe, concluded that most killing by the fungus followed as a consequence from annosus establishment in roots weakened by soil saturation or lack of sufficient aeration during a portion of the year. It seems quite possible that roots developed under normally quite low soil moisture levels might be more sensitive to the effects of periods of temporary saturation than those developed in a situation where the soil moisture level averaged higher. Moreover, much of the terrain on the east side is topographically more conducive to soil saturation when the moisture supply is sufficient to bring it about than that on the west side.

Whether or not the incidence of F. annosus on the east side is actually associated with temporary soil saturation in the spring remains to be demonstrated. At least it appears to be a likely hypothesis.

Bier.--Have you made any determination of the pH levels of soils where the annosus is found? Ans.: In a few cases where determinations were made, they averaged a little over 6 (6.2). This is slightly above the range of pH 4.6 to 6.0 found by Hopffgarten to favor the disease in Germany.

Bier.--One of our graduate students has been investigating the possibility that F. annosus might give trouble in thinned or cutover stands in British Columbia. He found that in our acid soils any annosus that became established was soon overwhelmed by Trichoderma. For this reason we have concluded that F. annosus is not likely to offer any threat to our regenerating stands.

Armillaria mellea

Gilbertson.--Three inoculation techniques were employed in an attempt to inoculate healthy western white pine poles with Armillaria mellea. The three techniques were as follows:

1. Infected white pine root sections placed in contact with wounded roots of healthy trees.
2. Dowells of white pine sapwood, 3/4 x 2 inches, were hollowed out and filled with a wheat-sawdust mixture. After inoculation with A. mellea, they were placed in the root with the apex of the dowell level with the cambium layer of the root.
3. A medium of wheat and white pine sawdust was wrapped in gauze, inoculated with A. mellea, and placed in contact with wounded roots of healthy trees.

After a period of two years, no roots were found to be infected as a result of these inoculations, although A. mellea was isolated from the original inoculum in all threetypes.

At the end of one year, half of the infected roots were severed between the point of inoculation and the tree to determine if the severed roots would become infected and in turn serve as a source of infection to the rest of the tree through the exposed root stubs. No cases of infection resulted from this procedure, and it was noted in a large number of cases that the severed roots had callused over and remained alive after a period of one year, indicating that root grafting of western white pine is quite common in these stands.

Leaphart.--Several thinning experiments were completed on the Priest River Experimental Forest, Idaho, in 1939 to emphasize release of western red-cedar. Two areas, approximately 1 acre in size, were thinned in one experiment to 400 cedar stems per acre and all the overstory was removed. Diameter

growth of the cedar on these plots was nearly 2.5 times greater than that of cedar on unthinned plots 10 years after thinning occurred. During the past 5 years, however, diameter and height growth has markedly reduced, the crowns of many trees have thinned, and some tree mortality has occurred. Armillaria mellea is present at the root collar in nearly all trees on the thinned plots but also in some trees on adjacent unthinned plots. This fungus had completely encircled the root collar cambial region when the dead trees were examined, but it is not known if this occurred prior to tree death. Similar cedar decline has been observed in some white pine stands in which most of a dense white pine overstory had been killed by pole blight. Whether this decline and mortality in cedar is caused by A. mellea, or is attributable to the exposure caused by thinning the overstory (cedar in white pine stands normally occurs as a subdominant throughout much of its rotation age), or is the result of a combination of both factors must still be determined.

Poria weirii

Leaphart.--To start the discussion on Poria weirii, I have made some observations in Region One that somewhat puzzle me. We have by no means made extensive surveys for the prevalence of Poria weirii in Region One, but so far we have observed it only within the white pine type. Douglas-fir occurs only as a subclimax species within this type and is suffering severe damage in certain areas, particularly the Coeur d'Alene National Forest. We have not found it (at least causing mortality) east of the Bitterroot Mountains where Douglas-fir occupies a climax or near climax position. I understand P. weirii is widespread in the coast-type Douglas-fir. While I admit we need to make many more observations in Region One to confirm the absence of Poria in our eastern Douglas-fir forests, is there any relationship between P. weirii incidence and climax associations?

Discussion.-- There was a short discussion on the relationship of Poria incidence and the occurrence of western redcedar as a possible explanation of the observations made in Region One. The people working on this root problem on the Coast indicated that the presence or absence of cedar in their stands had no bearing on the occurrence of P. weirii.

Childs.--In western Oregon and Washington we have found that hemlock very frequently escapes infection and may grow to full maturity in the presence of the disease, while the Canadians have found hemlock to be approximately as subject to damage as is Douglas-fir. In the west-side Douglas-fir region we feel that P. weirii is not a serious disease in climax types. It occurs principally in our pure or nearly pure Douglas-fir stands, which are distinctly subclimax or transitional in almost every instance.

Parker.--Gordon Wallis' work on the spread of P. weirii does not appear to indicate a correlation between the occurrence of the fungus in stands and the occurrence of cedar. However, most of his observations have been made in the coast and Columbia forests where cedar is widespread. Although cedar may not be present in certain fir stands where P. weirii occurs it is probably unfair to compare these stands with fir stands in the dry-belt regions. Even the occurrence of strains of the fungus capable

of attacking fir, but not cedar, would not preclude a common factor or set of factors affecting the distribution of both cedar and P. weirii. We hope to develop an effective inoculation technique so that such problems may be studied more readily.

Summary

Leaphart.--Because the time schedule did not allow for a planned discussion of what I considered to be a suitable ending for this subject, I have added the following post-mortem for consideration.

I previously suggested that our knowledge of tree host-root pathogen relationships is extremely limited despite the amount of investigative effort that has gone into this field. I believe the questions listed below have been neglected too often in previous research. For example, there would be no question today among pathologists of when, if, and how Armillaria mellea is a primary pathogen in relation to predisposing environmental factors often associated with its presence had answers been provided to these questions.

1. Have host vigor and environment and the ecology of the parasite and the rhizosphere been adequately studied in diagnosing the cause of root disorders?
 - a. What is the line of succession of fungi in invaded roots: which fungi came first?
 - b. What are the interactions of root-infecting fungi, saprophytic and other soil micro-organisms, and soil environment in any particular root problem?
2. What was the source of the pathogen's entry? How was this proved? Was the evidence only circumstantial?
 - a. How does infection occur under natural conditions and how can it be simulated in artificial inoculations?
3. How, when, and where can inoculum potential offset host vigor in relation to the micro- and macro-environmental influences?

Although this list may not be complete, I believe that the answers to these questions should be the objectives of all proposed root pathogen research, even if some are not attainable on the completion of a study.

POLE BLIGHT--HOW IT MAY INFLUENCE WESTERN WHITE PINE
MANAGEMENT IN LIGHT OF CURRENT KNOWLEDGE

Charles D. Leaphart

My original title was "Pole blight--its effect on western white pine management". Actually, without an established cause of the disease, I think that anyone would hesitate to predict our course in white pine management. Nevertheless the forest manager needs and is entitled to know what the future may hold and what steps he may be required to take to produce a mature white pine stand. I shall set forth my ideas of how we may have to manage white pine based on what we know about the disease to date.

Nineteen years ago the first research was started to determine the cause of pole blight, almost 10 years after it was first discovered. Neither at the time the disease was discovered nor when research into its cause was begun was the disease recognized as one representing a potential roadblock to and another milestone in the management of western white pine. I regard it as potentially the most serious disease of this species because a considerable acreage in pole stands is already affected and with the cause and control undetermined, it has a relatively unknown effect on all phases of white pine management.

Such a statement may sound strange to most of you who have recognized blister rust of white pine as its number one enemy. Today, in the Inland Empire, we are spending slightly more than \$1,300,000 annually to control blister rust and provide protection of white pine. The cost will represent approximately \$2.00 per thousand board-feet on the estimated future yield of this species from this area. The primary objective is to prolong the highest annual cut from present stands and to provide for an eventual annual cut of 500 million board-feet after 80 years. Pole blight may prevent full attainment of this objective or may necessitate material change in the direction of the white pine program. On some sites pole blight may break the 100- to 120-year rotation age, provided for in current management plans, at any age above 40 years. Not all pole stands are affected by pole blight, and we have reason to believe that some will never be affected. This has not been proved, however, and until the cause of pole blight has been definitely determined, most stands of the 40- to 100-year age class should be considered potentially susceptible to the disease. To what extent are we spending money for blister rust control to bring trees through the reproduction stages only to be affected by another disease? This question is of serious concern to all people involved in western white pine management.

Western white pine forests of the Inland Empire embrace an area of 3,600,000 acres (5). To date, 1,134,610 acres are within blister rust control units (9). Pole stands 40 to 80 years old occur on 304,420 of these acres; and reproduction stands 0 to 40 years old on 334,840 acres. Pole blight has caused 78,120 acres to be dropped from control units, about 7 percent of the present control area. It occurs on an additional 33,555 acres within 42 control units. Blister rust control and timber management personnel feel that with many unanswered questions on pole blight, certain calculated risks must be taken in selecting white pine

management units. Pole blight damage is one factor that lowers the classification of a white pine unit. Where the remaining estimated future white pine yield sufficiently justifies protection costs, the unit is retained in the white pine blister rust control program. The question is posed: How much of the reproduction acreage in the future will become infected with pole blight? Approximately two-thirds of the present reproduction acreage in control units lies north of the most southern known occurrence of pole blight.

White pine management is faced with still another problem in addition to blister rust. Approximately one-fourth of the total white pine acreage under control is in the pole-size class (9). The present acreage in the age classes that include the pole stands does not adequately provide for a sustained cut at present levels. Losses from any cause, including pole blight, will further aggravate the deficiency in these age classes.

The best available estimates show that nearly one-seventh of the present western white pine pole stand acreage is affected by pole blight. On this acreage slightly more than 50 percent of the white pine, based on basal area, is diseased or dead (2). When one realizes that more than 90 percent of the diseased trees are dominant or codominant individuals, that is, the crop trees, this figure is even more significant: it means that many of these affected stands will contribute little to the white pine industry.

What, then, might the forest manager do to combat this disease? Current and past research to determine the cause of pole blight has provided a number of leads and possibilities. At this point the more significant leads and their implications on white pine management should be discussed.

Ehrlich and Baker, ^{1/} Gill et al., ^{2/} Leaphart (3), Leaphart and Copeland (4), and McMinn (7) have demonstrated an abnormally high deterioration and mortality in the root systems of pole-blighted white pine trees and stands. McMinn concludes that a root pathogen capable of producing the deterioration of the structural system is not the cause of pole blight, but that the decline is systemic in nature accompanied by a reduction in mycorrhizal vigor (8). Studies on rootlet mortality and density and certain characteristics of soil underlying diseased stands tend to support this idea (4).

^{1/} Ehrlich, John, and Loren K. Baker. Preliminary study of dying of young white pine on Coeur d'Alene and Kaniksu Forests. Univ. of Idaho, School of Forestry. 50 pp., typewritten. 1942.

^{2/} Gill, Lake S., Stuart R. Andrews, and R. E. Millenbaugh. Pole blight investigations by forest pathology, 1948. Bu. Plant Indus., Soils, and Agr. Eng., Div. of Forest Pathology. 22 pp., typewritten. 1949.

The high deterioration in the root systems, particularly the fine absorbing portion of diseased white pine stands or of healthy stands within and adjacent to diseased stands, could be caused by pathological, entomological, physiological, or other agents. This deterioration in the fine root system is the hub around which pole blight revolves and is essentially the initial stage of pole blight. McMinn (8) believes that the subnormal root condition may be responsible for the development of the crown and stem symptoms or may simply be the result of a general physiological decline of the tree from some unknown cause.

The following observations suggest an edaphic-physiologic cause of pole blight:

1. No stands affected by pole blight have been found on soils having more than 5.0 inches of available moisture storage capacity in the upper 3 feet of soil, but the disease is commonly encountered on soils having storage capacities ranging from 0.7 to 5.0 inches. The average available moisture storage capacity for 113 diseased plots studied to date is 3.32 inches. Roots are able to grow in only 68 percent of the top 36 inches on these plots. This compares with an average 4.09 inches of storage capacity and 78 percent of the 3 feet available for root activity in 187 healthy plots in diseased areas, and 4.78 inches and 93 percent in 52 healthy plots in healthy areas. These observations show that, with fewer factors like rock and hardpans limiting soil depth, a significantly greater opportunity for uniform root growth and distribution is provided for in the healthy plots, particularly those in healthy areas.

Among the white pine pole-size stands affected by pole blight, those having lower storage capacities are significantly more damaged by the disease than those having high capacities. Within diseased stands this soil moisture factor accounts for only 15 percent of the variation in the percentage of white pine basal area damaged. Apparently, other factors such as the time period that a stand is affected, the normal biological processes involved in tree deterioration after stand vigor is reduced and mortality starts, and others, mask or confound the real significance of the soil moisture factor in contributing to stand decline. Previous studies (4) showed that white pine rootlet mortality and rootlet density were closely correlated with available moisture storage capacity. Though both rootlet mortality and a reduction in rootlet density have not been proved as a cause of pole blight, these two studies lend more significance to the role that soil moisture plays in pole blight decline than has been apparent heretofore.

Although both uniform root growth and available moisture storage capacity of the soil are quite significant in determining the health of a stand, adequate soil moisture distribution and

availability from sources other than precipitation (soil moisture recharge potential ^{3/}) are also important. A recent soil survey of 319 plots in pole-size white pine stands located throughout the white pine type in northeastern Washington, northern Idaho, and western Montana showed that pole blight incidence was correlated with available moisture storage capacity and soil moisture recharge potential, exclusive of direct precipitation (exceeded the 1 percent level of significance). Of all the recorded data that included ground cover density and composition, basal area per acre of all tree species, site index, and soil depth to zone limiting root penetration, only the two soil moisture factors were correlated with disease occurrence. They accounted for 70 percent of the variation in the incidence of pole blight. The percentage of 100 randomly selected white pine sites that might become diseased is predicted for various levels of recharge potential and available moisture storage capacities in table 1.

^{3/} Soil moisture recharge potential is considered here to be the movement, distribution, and availability of underground water. The following factors were used to estimate the relative potential for soil moisture recharge, that is, good, moderate, or poor, for a particular site: steepness of slope, site location and position on slope (ridgetop, bottom, bench, mid-slope, etc.), the surface area and topography above a site contributing to water storage, location with respect to existing water points (living or intermittent springs and streams, seepage areas, etc.), depth to water table, soil depth and characteristics, and parent geological material and structure.

Table 1.--The percentages of randomly selected western white pine sites that might become diseased as predicted for various soil moisture recharge potentials and available moisture storage capacities.

Available moisture storage capacity	Soil moisture recharge potential		
	Good	Moderate	Poor
	<u>Percent stands affected</u>		
0.0	67.10	82.80	98.50
.4	61.54	77.24	92.94
.8	55.98	71.68	87.38
1.2	50.42	66.12	81.82
1.6	44.86	60.56	76.26
2.0	39.30	55.00	70.70
2.4	33.74	49.44	65.14
2.8	28.18	43.88	59.58
<u>1/</u>			
3.2	22.62 ± 4.94 ^{2/}	38.32	54.02
3.6	17.06 ± 4.92	32.76	48.46
4.0	11.50 ± 4.88	27.20	42.90
4.4	5.94 ± 4.92	21.64 ± 4.57	37.34
4.8	.38 ± 5.03	16.08 ± 4.70	31.78
<u>1/</u>			
5.2	.00	10.52 ± 4.91	26.22
5.6	.00	4.96 ± 5.18	20.66 ± 5.53
6.0	.00	.00	15.10 ± 5.85
6.4	.00	.00	9.54 ± 6.20
6.8	.00	.00	3.98 ± 6.60
7.2	.00	.00	.00

1/ These lines delineate risk classes described later (page 59)

2/ Fiducial limits at 95 percent probability.

2. Climatic records show that white pine stands went through a period of low precipitation and high temperature from 1917 to 1940. Since that period, certain years (some successive) have had below normal precipitation. Using records of certain stations both near and outside pole blight areas, Wellington (10) found a highly significant relationship between the occurrence of pole blight and both summer precipitation and temperature when combined in a multiple analysis. Dendrochronological records (6) suggest that the period climaxing in 1929-30 was the driest ever experienced in the past several centuries within the white pine type. McMinn believes that such an adverse climatic condition might affect white pine more severely than other species, or that recovery from ill effects may be less rapid (8). Of the species commonly found in association with western white pine, only western hemlock, grand fir, and western redcedar also have fairly narrow climatic and geographic ranges. Western larch, Douglas-fir, and lodgepole pine are commonly found on drier sites than those where one normally expects to find white pine. Grand fir, to a lesser extent, also occurs on drier sites than white pine. On the fringe of its type, white pine is limited to the creek bottoms, sites within and just below spruce basins, or other moist situations. Western hemlock, western redcedar, grand fir, and Engelmann spruce are compensated in other ways, to be explained later, when moisture stresses might be detrimental to tree health.
3. Primarily, age, site quality, and basal area determine rootlet density in healthy white pine stands (4). Rootlet density begins to fall below a standard of 100 percent at about the age of 100 years. Normal pole stands have a density equivalent to 190 percent, while in diseased stands it is about 65 percent. Healthy stands adjacent to diseased stands have nearly the same density as diseased stands. Rootlet mortality at any given sampling in normal stands is about 3.5 percent, in healthy stands in diseased areas about 6.5 percent, and in diseased stands around 9 percent. In studying individual trees, Ehrlich and Baker 4/ and McMinn (7) found that rootlet mortality runs as high as 100 percent in severely diseased trees. Just where the threshold of tree vigor lies in determining whether the remaining rootlets die because of internal physiological causes instead of environmental or pathogenic factors is not known. However, an intense reduction in tree vigor and internal physiological stresses probably causes much of the rootlet mortality in severely diseased trees.
4. Although fundamental studies are now in progress to determine the effect of moisture deficiencies and stress on rootlet mortality, some empirical information has been accumulated. Rootlet mortality studies made from 1952 through 1955 showed a considerable variation in mortality rates from one year to the next (4). Rootlet mortality in western white pine for all areas sampled in 1952 and 1953 ranged from 10 to 26 percent but only from 2 to 15 percent for 1954 and 1955. Using annual weather records of stations apparently similar in climatic variation to those of the root study areas, a regression analysis showed that rootlet mortality in all areas studied during the 4 years increased significantly

4/ See footnote 1.

as total summer precipitation, June 1 through September 30, decreased. Such observations suggest that moisture stresses directly influence rootlet mortality: the studies now under way should throw considerable light on this possibility.

5. Root studies made in a stand affected by pole blight suggest that all other tree species are better able to compete for available moisture than is white pine, considering rootlet density and length as the only measures of competition (3). Both rootlet density and length of western hemlock, western redcedar, grand fir, and Engelmann spruce are two to four times greater than western white pine. Those species like western white pine are restricted by climatic or other conditions where moisture appears limiting to their growth and occurrence. Of the four species, only cedar, grand fir, and hemlock occur in any great quantity on pole blight areas, but they are usually subdominants to white pine. Although they have a higher exposed needle surface on an equivalent basal area basis, their evapotranspiration stress should be lower since they normally occupy a lower crown position than pine, but we need definite information on this point for all crown classes.
6. Experimental thinnings and salvage operations indicate no cutting method currently in use effectively retards or halts progress of the disease (1). If moisture deficiencies alone were the cause of pole blight, cuttings or thinnings should improve the moisture regime for white pine and reduce or prevent the damage caused by pole blight. On the other hand, residual stumps provide a source for the buildup of inoculum of fungi like Armillaria mellea. In pole blight or pole blight susceptible stands, observations suggest a reduction in general stand vigor that sets up an ideal situation for a buildup of Armillaria, for example. This fungus could prolong and intensify general stand deterioration, the symptoms of which resemble or combine with normal pole blight symptoms. Similarly, once mortality from pole blight starts in a stand, almost the same opportunity for pathological buildups occurs as for one resulting from a thinning operation. Perhaps this explains in part why stands continue to suffer from pole blight during the present climatic cycle that seems relatively favorable for white pine growth. In addition, any thinning of a stand produced artificially or by excessive mortality, might increase evapotranspiration in the residual dominant and codominant classes of trees. If this does not occur, an additional stress is placed on an already subnormal root system to supply the tree's increased demand for moisture. Hence a continuation or even an intensification of pole blight occurs within a stand once pole blight mortality starts or a thinning is made at a critical time in the life of a stand.
7. Studies of other species suggest that the period of highest physiological activity starts fairly early in a tree's life, between 20 and 40 years of age. Maximum competition and stand closure occur at approximately 30 years in western white pine stands. Volume production of wood is just starting into its peak at this age also, reaching a maximum near 60 years for the average site. Pole blight

affects the stand during the period, predominantly the 60-year age class, and primarily the dominant class at that. If one adds a period of severe moisture stress and an inadequately absorbing root system at this critical stage, the relationship acquires even greater significance.

A summary of the investigations on other possible causes of pole blight reveals considerable voids in our knowledge of their relationships to the disease. One generally assumes that any virus, fungus, or insect contributing to the pole blight decline is able to operate effectively only under the predisposing soil factors previously highlighted. Nevertheless, the following observations merit consideration in formulating recommendations that might be made for control of this disease.

1. No fungus has been isolated and identified as the cause of rootlet deterioration. Armillaria mellea is recognized at present as the most predominant root pathogen in white pine pole stands. Leptographium spp. have frequently been isolated from diseased trees and have killed white pine roots under artificial inoculation conditions. Root and stem inoculations with this fungus have not reproduced pole blight symptoms. Though some other organisms were isolated even more frequently and shown to have an ability to destroy white pine rootlets, I would hesitate to assign sole responsibility to it as the causal organism. If a fungus (or fungi) is responsible for root and rootlet deterioration, it appears to be neither virulently pathogenic nor introduced, but instead to be an indigenous pathogen of opportunity.
2. No virus has been detected in the various tests to date. Although no virus has yet been found affecting a conifer, one might be present in western white pine and responsible for pole blight. More intensive research is needed to prove or disprove the presence and importance of a virus.
3. No primary insects that could cause rootlet deterioration have been found in stands affected by pole blight. Although parasitic nematodes have been observed in white pine pole stands, no proof of their parasitic potential on white pine or of their relationship to pole blight has been presented.
4. With the present knowledge on the distribution of pole blight and its relationship to certain soil characteristics, should one stop future research if some organism or physiological requirement is discovered that will reproduce all or part of the pole blight symptoms in healthy trees? Apparently, from this point on, research must run the entire gauntlet of possible causes to determine whether this pole blight problem is one specific disease, or a complex of different disorders.

While different interpretations could be put on these factors, they suggest that the cause of pole blight is basically physiological. The recommendations for future white pine management that might be made using the above knowledge on edaphic-physiologic relationships are essentially as follows and are based upon our ability to (1) classify all sites by the two soil

characteristics, effective soil depth and available moisture storage capacities, (2) predict the probability of recurring dry cycles similar to the one occurring in the past 50 years, and (3) develop accurate and standard means of judging amount, depth, and duration of underground water flow for any site.

1. Blister rust control units, both present and potential, for white pine management would be classified on the basis of three risk categories with the following descriptive limits:
 - a. High risk.-- Sites within the range of available moisture storage capacities and recharge potentials occurring above the dotted line in table 1. If white pine is to be grown, it would be on short rotations of 40 to 60 years. Longer rotations will be determined by long-range climatic cycles.
 - b. Moderate risk.-- Sites within the range of available moisture storage capacities and recharge potentials occurring between the solid and the dotted lines in table 1. Pole blight will occur on some of these sites, especially if the white pine stands reach 40 years of age at the start of the decline in a low precipitation, long-range cycle. Rotations could be planned for 100 to 120 years but may be shortened for certain sites depending upon climatic factors and the limitations in underground water flow.
 - c. No risk.-- Sites within the range of available moisture storage capacities and recharge potentials occurring below the solid line in table 1. Rotations for growing white pine could be planned for 120 years and longer.
2. High- and moderate-risk categories will usually occur north of the line running generally east and west through Laird Park on the St. Joe National Forest. Few areas north of this line will fall into the no-risk category.
3. Sites receiving less than 30 inches of annual and 5 inches of summer (June 1 through September 30) precipitation over consecutive periods of 2 or more years in the past would normally fall in the high- and moderate-risk categories.
4. Effective soil depth noticeably influences root penetration. Pole blight occurs on a few soils in which all of the top 36 inches of soil mantle are available to root growth, but in general such soils are subject to little or no underground moisture recharge. Where soil depths are limited by hardpan layers or by rock, such sites would seldom fall in the no-risk category. If the effective soil depth extends one or more feet past the 3-foot limit, the site would usually be classed as no risk.

The foregoing risk classification is one possible means of approaching control of pole blight if future research does not reveal a more direct cause. Should the cause be proved directly associated with a

fungus, a virus, an insect, some specific physiological requirement, or any combination thereof, recommendations for management could be along any of the following lines.

1. A genetics program might be undertaken to develop planting stock resistant to the causal agent. Several considerations must be faced, however, if a genetics program is to be launched: (a) That a development program for producing stock resistant to blister rust is already under way. If both the rust-resistance factor (or factors) and a pole blight resistance factor are to be developed in one plant, the chances of success would be decreased and the feasibility and cost of undertaking such a program might be impracticable. If physiological causes are involved, the problem may simply be one of developing an elite tree resistant to blister rust and possessing, for example, an ability to produce a fibrous root system under all site conditions. (b) That if resistance is to be obtained for a single pole blight cause but only at the expense of the blister rust resistance factor, it might be desirable to initiate a project toward developing pole blight resistant stock in addition to the project for blister rust. Stock from the latter would be used to plant in areas where no pole blight is likely to occur. Stock with the pole blight resistant factor would be planted in susceptible areas where control of blister rust can be obtained by our present practices.
2. If the agent or agents causing pole blight are associated with rootlet mortality, probably no recommendations for direct control would be economically feasible under natural stand conditions, particularly for fungus or "nematological" causes. However, a vector for a virus might be subject to normal entomological control.
3. Recognizing that some agent may be the direct cause, it may be impossible to develop resistance to it or to apply direct control measures. Only one alternative would be left--to manage white pine on a risk classification built around soil factors influencing soil moisture. This drastic measure would restrict volume production of this species in the next rotation much below the present demand.

A re-evaluation of the Matthews-Hutchison report (5) has recently been considered and, if initiated soon, would come at a time opportune for a number of reasons. Such a study would aid both research and management in visualizing more accurately the future of western white pine and might suggest just where to go from here. An analysis of this nature should include comparative values and costs of growing associate species. Most important, it would determine how much margin exists to cover the possible costs of pole blight control to perpetuate white pine as a commercial species on high-risk areas before one would be forced to convert these areas to growing other species.

Perhaps not enough facts on pole blight are available to guide our thinking on western white pine management. However, on more than 350 plots scattered throughout the white pine type in the Inland Empire, pole blight has not been encountered where soils have an available moisture storage capacity greater than 5.0 inches nor where they are characteristically deep, exclusive of the pure sands. Also, the disease has not

spread into the southern part of the white pine type, nor, with few exceptions, into stands that were healthy 4 years ago. A framework is available on which to advise forest managers, but it involves a certain risk that cannot be fully calculated at present.

Future research on pole blight will be more specialized and therefore more costly and time-consuming. Projects, such as virus studies, physiological studies, and isolation studies to be followed with Koch's postulates for proving pathogenicity, will take years to complete. Although the cause of pole blight may still remain a mystery, valuable information will assuredly be forthcoming from such studies. However, without more knowledge which research must provide, forest managers would be forced to resort to risk management. A period of 10 to 15 years of research and observation on trends of the disease may be necessary to show if the proposals outlined here are in fact real.

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Moderator's summary

Don has emphasized the growing importance of pole blight in the management of white pine. He has pointed out that of the total acreage of white pine under control for blister rust only one-fifth is of pole-size class, which by itself is considered inadequate to provide a sustained yield of white pine. The relatively large incidence of pole blight within this class further reduces its potential as a future crop. As a result he feels it would be expedient to reduce our present cut of mature white pine so as to cover these future losses. This would serve to reduce the pressure which presently bears on white pine management, and would provide a breathing spell to find answers to the pole blight problem. On the basis of our present knowledge on pole blight he has brought together a number of facts which suggest an edaphic-physiological cause of the disease. Chief among these would appear to be severe moisture stress and an inadequately absorbing root system which coincides with the relatively late period of highest physiological activity for white pine. In most other species, maximum activity occurs between 20 and 40 years.

His analysis of the facts has virtually eliminated the possibility that any known pathogen is responsible for the disease, although certain fungi, namely Armillaria mellea and Leptographium may play an important part in aggravating the condition to the extent that these fungi must be considered in management and control procedures for diseased stands.

The rating of stands of white pine by risk classes based on our present knowledge of how different soil moisture conditions may operate to predispose stands to the disease has been recommended pending the discovery of a specific causal agent. If a specific cause should be found then control measures might be utilized based on the development of resistant trees, but this would have to take into account the fact that stock resistant to blister rust is already available.

Discussion by membership:

Wagener.--Does soil saturation have a bearing on the condition?

Buchanan.--Could soil moisture factors have indirect effect on disease by influencing soil microorganisms such as mycorrhiza? Could not mycorrhiza fill the requirements of a disease pathogen?

McMinn.--On mycorrhiza situation--difficult to know what mycorrhizal organisms or structure are doing to the host. It seems these organisms in the roots, in any case, are going to get what they can and give very little.

Gilbertson.--In pole blight trees examined, dead cortical tissues of healthy roots are consistently inhabited by fungi. There are no mycorrhizal structures present but there are fungi. However, these have no clamp connections.

Bier.--Possibly (trace) element deficiency rather than moisture deficiency responsible--not enough to tide tree over in time of moisture stress.

DWARFMISTLETOE AND ITS RELATION TO PONDEROSA PINE MANAGEMENT

Keith R. Shea

Ponderosa pine commonly is parasitized by two species of dwarfmistletoe. In the Southwest and southern Rocky Mountains, Arceuthobium vaginatum f. cryptopodum (Engelm.) Gill attacks Pinus ponderosa var. scopulorum Engelm.; whereas A. campylopodum f. typicum (Engelm.) Gill is found on Pinus ponderosa Laws. to the west and north (Gill, 1935). For the most part, the dwarfmistletoes are confined to a narrow host range with crossovers such as those reported by Hawksworth (1956) and Weir (1916) being rare or of little economic significance. This discussion will be confined to A. campylopodum f. typicum, especially as it is found in southern Oregon except for analogies which can be drawn from the more complete work in the Southwest.

Damage.--Dwarfmistletoe is a primary cause of damage to ponderosa pine throughout Washington and Oregon. Accurate evaluations of the loss attributable to this parasite are not available; however, the Northwest Pest Action Committee (1955) estimated the annual loss in yield at 38 million board-feet. This appears to be a conservative estimate. For example, in the Southwest, Hawksworth and Lusher (1956) have shown that mortality in infected stands was approximately 1.8 times as great as in uninfected stands. This averaged about 48 board-feet per acre per year in mistletoed stands and 27 board-feet in uninfected stands. Although Gill (1954) has pointed out that A. vaginatum appears more aggressive than A. campylopodum, losses in this region must be more severe than realized.

Distribution.--The distribution of dwarfmistletoe is an important aspect of ponderosa pine management. Roth (1953, 1954) has shown that usually it is found in a patchwork pattern with certain portions of the stand being attacked more severely than others. Concentrations of heavily infected young trees commonly are found around infected overstory trees from which vigorous mistletoe plants have dispersed large quantities of seed. Moreover, severely infected, localized areas appear related to topographic features, and stand structure and history (Roth, 1954; Gill, 1954). Such observations would indicate that microclimate could influence the abundance of dwarfmistletoe in a given situation. If so, manipulation of a stand to form environmental conditions adverse to disease development may be possible. At any rate, the patchy distribution of infected trees makes this parasite susceptible to control by silvicultural practices. Either the infected areas can be isolated or they can be effectively cut and pruned to eliminate or reduce the pathogen to an innocuous level. Both require intensive management plus favorable economic conditions.

Spread.--The manner by which a pathogen is spread is of considerable importance in developing control plans and evaluating the potential threat to the forest. Roth (1953, 1954) has shown that the greatest spread of infection was from the overstory to the understory. This suggested much slower spread through even-aged stands lacking an infected overstory. He found also that mistletoe seeds were dispersed in an ellipse around infected overstory trees (185 by 118 feet around one tree). Heavy infection was concentrated within 33 feet from the overstory source. Similar observations have been reported from the Southwest (Gill, 1954; Gill and Hawksworth, 1954). Roth (1954)

also noted that the spread appeared greater in the direction of prevailing winds; whereas, Gill and Hawksworth (1954) did not confirm this in the Southwest. Obviously the local conditions can limit the distance and pattern of seed dispersal around an infection source. However, these distances for seed dispersal are so slight that infections tend to remain localized unless long-distance dispersal is brought about by other factors such as man, animals, and storms during seed discharge.

Control.-- The only known method for attempting control of dwarfmistletoe once it is established is to cut the tree or remove the infected branches. Although time-consuming and expensive, the benefits in individual tree form and in stand improvement may warrant these silvicultural treatments. In the Southwest, extensive control was undertaken on about 12,000 acres at an initial cost of \$4.17 per acre (Hawksworth and Lusher, 1956). Follow-up operations planned within 6 to 10 years are to treat trees with latent infections. Such an undertaking might be considered on an experimental scale in this region.

The pruning of infected branches to eliminate dwarfmistletoe raises the question of what constitutes a prunable infection. To answer this question, a study was initiated by the author (Shea, 1957). In each of two areas in southern Oregon, 2 branches of ponderosa pine with localized dwarfmistletoe infections were collected from each of 18 combinations of 3 branch diameters, 3 branch heights, and 2 distances from the tree bole to the proximal end of the external swelling associated with infection. Each branch was dissected and examined microscopically to determine the relation of the endophytic system to the associated swelling. Analysis of variance brought out the significant effect of an increase in branch diameter on both the endophytic system and the corresponding swelling. Branch height and distance of the swelling from the tree bole showed no consistent effect on the extent of either the endophytic system or the swelling. Highly significant, positive coefficients of correlation were found between the swelling and the corresponding endophytic system for both proximal and total lengths. The relationships discovered suggested that dwarfmistletoes could be pruned safely from trees when the proximal end of the swelling was over four inches from the tree bole. Hawksworth has indicated in personal correspondence that the extent of the endophytic system appears correlated with branch diameter in the Southwest, such that, branches 1, 2, and 3 inches in diameter can be pruned provided no shoots are within 4, 6, or 8 inches of the bole, respectively.

Eradication of the parasite by chemical means holds promise. To date, success is lacking but some chemicals show promise (Gill, 1955). The problem is to find a material which when applied or injected into a tree will eradicate the mistletoe without permanent damage to the host. The development of more effective chemicals and means for their economic application is an urgent need. Currently, dwarfmistletoe of ponderosa pine is the subject of team research in which Dr. John Rediske is initiating significant physiological investigations. Using infected pine bough cuttings, radioisotopes of iron, iodine, and phosphorus, and an autoradiograph technique, he has demonstrated that the mistletoe plant has access to both the host xylem and the phloem. Hence, it would be

susceptible to control applications channeled through either of these tissues. Therefore, direct spray contact with the parasite might be unnecessary if the proper systemic can be found.

Research on silvicultural control of dwarfmistletoe on ponderosa pine in southern Oregon was initiated on Klamath Falls Tree Farm by the author during the summer of 1957. The study is concentrated in dense sapling stand under a residual overstory left after a diameter limit cutting. Twelve 0.5-acre plots selected for study averaged 5,150 stems per acre or 169 square feet of basal area. Dwarfmistletoe was severe on all plots; the percent of the trees infected ranged from 21 to 78 and averaged 57 percent. The basal area infected ranged from 31 to 91 percent, averaging 68 percent. Of even more consequence was the distribution of infected trees by size classes (table 1).

Table 1.--Incidence of dwarfmistletoe by diameter classes on twelve 0.5-acre plots in understory ponderosa pine stands in southern Oregon

DBH class, inches	Infection, percent	Number of trees, basis
Less than 1	18	183
1	41	1,134
2	60	897
3	72	519
4	73	256
5	69	91
6	85	39
7	91	11
8	100	6
9	100	2

The preceding data suggest that larger trees in the understory act to screen the smaller ones from an infection source in the overstory. The number of both stem and branch infections on the larger trees indicate what silvicultural treatments are required to reduce mistletoe infections. Thinning from above should prove practicable since ponderosa pine has been reported to

respond favorably to release (Curtis, 1952; Mowat, 1950). However, Mowat (1953) has pointed out that it is questionable whether to favor dominants or a larger number of codominant trees in a stand.

Initial thinning of our plots on Klamath Falls Tree Farm served to eliminate non-prunable infected trees and to improve spacing in the leave stand. The cubic content of all trees cut in the understory which would produce an 8-foot bolt to a 3-inch top diameter inside bark ranged from 46 to 340 cubic feet per acre, and averaged 152 cubic feet. If this volume were merchantable, it could support a substantial portion of the cost of sanitation. Additional benefits would be gained from accelerated growth rates in the remaining stand. In addition to the cubic volume removed, approximately 1,000 board-feet per acre was cut to eliminate overstory sources of infection within one chain of the plot boundary. In the present study, the average diameter of the understory was about 2.1 inches with an average of 937 trees per acre left after treatment which is equivalent to approximately 7-foot spacing. The considerable number of stems seemed desirable since repeated treatments may be required to eliminate latent infections or those missed during the first treatment. The spacing of leave trees is of the same order as Mowat (1954) suggested (8 feet for trees of 2-to 3-inch diameter).

Discussion

Management of ponderosa pine is made up of silviculture, utilization and economics. Even more critical are the limitations imposed on management by the several facets of protection. Quite elementary is protection against fire; nearly as essential is the risk of loss to bark beetles; of mounting significance is the degrading through injury by porcupines. Of comparable significance is the drain on growth and yield imposed by dwarfmistletoe infections. Here we find that the involvement of pathology with the other aspects of protection is the very nerve center of the development of feasible joint management of ponderosa pine.

Mistletoe-infected trees can be discriminated against and automatically placed in a high-risk category regardless of other crown characteristics. Field observations have indicated that infected trees possessing a vigorous crown frequently are the greatest threat as a potential infection source for surrounding reproduction; hence, such trees should be removed. In marking mistletoe-infected trees the forester should keep in mind their relation to surrounding vegetation. Are other pines threatened; is reproduction present, if so, is it primarily ponderosa pine or some other species? If the answers to these questions are "no", the tree may be left provided other characteristics do not place it in a high-risk class. Such practices in which infected overstory trees are eliminated where they are a threat to surrounding trees should do much to alleviate the situation and reduce damage although Gill and Hawksworth (1954) have shown that satisfactory control can be achieved only when treatment of the overstory is applied without compromise. Once overstory sources of infection are eliminated, it may be possible to wait several years without appreciable damage before sanitizing dense stands of reproduction. By that time, research may have

progressed and utilization standards may have changed until treatments which incorporate sound silvicultural practices and pathological considerations can be attempted on an economic basis.

Meantime, foresters and specialists in various fields should continue to develop new concepts to guide the management of ponderosa pine. Both fundamental and applied research are needed. Among the factors requiring additional consideration are biological studies on the parasite, the host, and their interactions including the relation of microclimate to epidemiology; evaluation studies to develop methods for surveys including the location of diseased areas and techniques for appraising damage; and control research to investigate further the possibilities of silvicultural control and to develop chemical controls based on fundamental studies involving nutrition, translocation, and systemics.

Currently, researches on various aspects of dwarfmistletoe are being conducted by our specialists. Included are investigations on minor element nutrition and translocation to explore possibilities for chemical control. Studies are being made to develop methods for artificial inoculation so that resistance may be tested, dated infections obtained for experimental purposes, and the life cycle ascertained. Surveys have been initiated to aid in management practices and experiments in silvicultural control are under way.

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Moderator's summary

Keith's discussion has been concerned with Arceuthobium campylopodum f. typicum as it occurs on ponderosa pine in southern Oregon, and some reference has been made to the work on mistletoe in the Southwest.

He suggests that the patchwork pattern of distribution of dwarfmistletoe in this area is such that control by silvicultural practices may be possible. Factors that influence the spread of dwarfmistletoe in a stand are therefore of prime importance in assessing the feasibility of any control measure.

Regarding chemical control, the effect of direct contact sprays on the rate of development of the endophytic system might be a profitable experiment for, if it can be slowed down considerably, spraying might be recommended as a temporary measure where for economic reasons it might be necessary to delay a pruning operation for several years.

Another approach might be in the development of a chemical agent which would prevent flowering or fruiting of the parasite thus providing for an effective control of spread until efficient systemics are found. Even the contact sprays already tested which are found wanting in total killing effect might be found suitable for this purpose.

Discussion by membership:

Leaphart.--Perhaps the patchwork distribution of mistletoe is associated with fire history rather than the microclimate. Microclimate has an effect on seed dissemination and pollination, although fire history has an important effect.

Roth.--Some trees are resistant to the disease. Example of a case where two or three trees were essentially free (from mistletoe infection) in a heavily infected area.

Roth.--Germinability of seed demonstrates a wide range of variation so the quality of seed will reflect in the success or failure of inoculations.

DIEBACK AND CANKER OF YOUNG DOUGLAS-FIR

W. A. Porter

Repercussions of the November 1955 sudden cold period are still being observed in the coastal Douglas-fir (Pseudotsuga menziesii (Mirb.) Franco) of British Columbia. These occur in the form of a leader dieback and a stem cankering among the reproduction and sapling-sized trees on certain areas. The height class affected is from 1 to 40 feet, generally around 20 feet, and the ages range from 2 to 30 years, but generally about 15-20 years. The injury caused by this cold period to the 1955 tissue varied greatly between trees. Some trees were totally unaffected. On others, the damage ranged from scattered needle killing and defoliation to apical and lateral bud damage, and also dieback of leader, laterals and cankering on certain parts of the bole. Frequently, leader growth up to 4 feet long was entirely killed.

Damage in these young stands amounts to 1 - 2 percent of the dead leaders throughout the species range on Vancouver Island and the adjacent mainland coast. On the Island, two different regions of concentrated damage have come to the attention of the Victoria Laboratory. One region at Salmon River showed 22 percent damaged leaders over 150 acres of mixed natural regeneration and plantations. The other, at Sooke, showed 52 percent damaged leaders over an estimated area of about 2,000 acres of natural regeneration. The first location is some 200 miles north of Victoria on the east side of the Island, while the latter is located 40 miles away on the southwest side. Trunk cankering is chiefly restricted to the Sooke region. It is here that 7 percent of the damaged trees are now dead, and many of the remainder are expected to die within several years.

The chief reason apparently for the severe degree of damage at Sooke is its extreme exposure. The land rises gently and continuously from sea level to an elevation of 2,400 feet, all with a southern aspect. The soil, while thin, gravelly, and lacking ground water during the growing season, has

previously supported a heavy stand of fir, hemlock and cedar. The present regeneration was established 15 years ago, following a very heavy slash fire after logging. Ground cover is almost negligible. While running over 90 percent to Douglas-fir, the land is not fully stocked since there are only, on the average, 400 trees per acre (based on figures from the sample plots).

The silvicultural repercussions of this damage include a marked deformity of the bole. This has occurred when many laterals on lower whorls competed for leader dominance after the original leader was killed. Where trees have died, the species stocking and age composition will change considerably.

The pathological repercussions include the continuing presence and activities of fungi normally considered as saprophytic or weakly parasitic under conditions of host injury or weakening. This is of interest in the concept of the interrelationships between the normal fungal populations of an area, the host plants, and their environment.

The host weakening in the case of this damage was adequately performed by the air environment. It consisted of cold dry polar continental air masses, which swept suddenly onto the non-cold-conditioned forests of the Pacific Northwest. A survey report on the extent of this damage in western United States has been published by Duffield (1), and a note on observations in British Columbia by Porter (2). Hemlock and cedar regeneration was not damaged as severely in British Columbia as in Washington.

The weather conditions on the coast during November 1955 are worthy of recounting. Mild, moist conditions prevailed in October and up to November 11. Then dry winds, with velocities up to 40 m.p.h., some light, dry snow, and temperatures all below freezing, with maximums averaging under 27° F., existed for the next 7 days. The plants in the region were not winter-conditioned and many exotic ornamentals normally hardy were killed outright. In native trees, the reproduction was damaged. Injury to mature trees has been considered negligible, although recent losses from an unexplained cause in mature hemlocks near this same area have been reported.

Histological examinations of damaged Douglas-fir from Sooke shows a well-defined frost ring at the juncture of 1955 summerwood and 1956 springwood. This ring consists of an abnormal area of cells containing crushed and distorted xylem and parenchyma elements, all resin-soaked with abnormal resin canals and epithelial cells. Wood rays are also distorted. A similar condition has been reported previously by Rhoads (3). The frost ring completely girdled the tree, including branches, except for those areas where the cambium was killed.

Cultural isolations from damaged tissue have yielded primarily two different organisms. Dasyscyphus pseudotsugae is associated with trunk cankers, and Stereum sanguinolentum (Alb. & Schw. ex Fr.) Fr.

is associated with decay from damaged leaders. Other fungi isolated frequently from the damaged leaders or laterals include Pullularia pullulans, Phomopsis sp., and Cytospora sp.

All of the trunk cankering has been initiated at the upper junction of either lateral branches, or small twigs, dwarf shoots, or buds. The imperfect stage of Dasyscyphus was generally observed fruiting in the spring on necrotic areas of the trunk. The perfect stage was occasionally observed in the summer on the same areas following a moist period. To appreciate the reason for damage at these specific locations on the bole, it should be recalled that these are the regions where meristematic activity occurs first at the start of the growing period, and also where it concludes at the cessation of growth. Thus such places are most susceptible to late frosts. No frost ring was formed on these areas after the cambium was killed. Any moisture retained in the bark ridges after drying and cracking at the upper junction of lateral branches with the trunk could provide an excellent infection court for fungi. Excessive bark ridging is more noticeable in the damaged trees than in healthy trees. It is noteworthy that the cankered areas associated with Dasyscyphus increased in size and tended to coalesce more during the host's dormant period than during its active growth period. This caused a death of laterals immediately between cankered areas. Artificial inoculations made in the field at the start of the 1956 dormant season with this fungus have only been successful where bark wounds were made. While the more vigorous trees have in part calloused over some of the cankered areas, no definite cases of recovery have been noted at Sooke on the tagged plot trees. The natural source of inoculum in the field has not been located. The continued activity of this fungus in the damaged trunks is considered a new observation on its parasitism as previously observed by Hahn (4).

In addition to the above damage and frequently on the same tree, Stereum sanguinolentum has been isolated from sapwood and heartwood. The large parenchyma cells of the pith seem to provide a quick and easy method of longitudinal spread from damaged top down to root crown. Here heartwood is just starting to form in this age class. The fungus is cultured readily from these living, damaged firs. Lateral spread of this fungus has been temporarily halted within the 1955 cylinder of wood, in some trunk portions, by the resin soaked frost ring. However, in many places lateral spread has occurred through wood rays into the 1956 and 1957 wood. Fruiting bodies of S. sanguinolentum in several cases were produced on the under side of dead laterals. The foliage browning, then death, of progressively lower branch whorls is observed on most of the damaged trees at Sooke. Recovery of the trees does not seem possible, even of very vigorous individuals. If any do live, this fungus will undoubtedly be a serious factor in successful recovery of usable volume.

Inoculations in both field and greenhouse are continuing with cultures of the fungi to obtain further evidence on the amount and degree of host weakening required for pathogenicity. An index of herbarium specimens and cultures obtained from this study is being compiled. The inoculation of rooted cuttings from healthy and diseased trees is being contemplated in order to secure genetic uniformity of host material. Observations are continuing on the times of flushing and of "hardening-off" of healthy and diseased field trees. Initial results on a per-tree basis indicate a correlation between

absence of damage and early "hardening-off". Thus genetic differences between adjacent individual trees would explain in part the reason for frost resistance or susceptibility and consequent healthy or damaged condition.

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Moderator's summary

This is an example of how the pin-pointing of a particular climatic event can be useful in determining the effect of environment on the course of a disease. Here are discussed the effect of factors that act to predispose tissues to infection--the significant causal agent, and to follow the succession of organisms occurring in the injured tissues until the final manifestation of the disease is evident.

This investigation has provided a number of clues which are being developed further. These are the identification and nature of infection courts; the distribution of associated fungi and their preferences for specific sites; the mode of action of the pathogens; the effect of wound callus on the progress of the fungi; the nature and timing of fruiting of the fungi; genetic and environmental factors on variations in resistance of host tissues to infection.

With the date of the proximal cause established, as in this case, together with the fact that investigations were conducted in several widely separated areas, it might be possible to obtain additional information on the rate of growth of cankers associated with Dasyscyphus, the rate of decay caused by S. sanguinolentum and the differences in the progress of the organisms on different sites.

Discussion by membership:

Wagener.--Do you conceive that S. sanguinolentum made all that progress in 2 years' time (from top to roots)?

Porter.--No doubt in my mind that it did.

74.

Gilbertson.--Did you ever isolate Dasyscyphus and S. sanguinolentum from the same tree?

Porter.--This has not been done -- but no critical studies have been made.

WHITE PINE BLISTER RUST IN FOREST MANAGEMENT
IN WESTERN UNITED STATES

James W. Kimmey

The greatest influence white pine blister rust has had or will have on forest management in the West is to reduce the acreage of timber stands managed for the production of pines that are susceptible to the rust. All susceptible pine species including the commercially prized western white pine and sugar pine will cease to be minor components of most natural timber stands within the range of the rust, regardless of the intensity of forest management. However, it is feasible that resistant-bred pines may in time be planted as minor components of managed stands. In future western stands managed primarily for commercial timber production, only western white and sugar pines will remain from the rust-susceptible species, at least in the next few rotations. And these will be on acreages greatly reduced from the original commercial ranges of these two white pine species. However, these fewer acres will be managed primarily for these pine species, except perhaps in the southern Sierras of California.

Of economic necessity management must be more intense, and therefore more costly. And to these costs must be added the cost of blister rust control. Because of these added costs of management, tremendous acreage reductions will result. That is why in the Inland Empire, where western white pine forests embrace an area of 3,600,000 acres, the present program of white pine blister rust control work will protect less than one-third of this vast acreage, or 1,135,000 acres. Likewise in California's and Oregon's sugar pine areas where this prized tree species occurs on more than 2,000,000 acres of commercially available land, outside of state and national parks, blister rust control is being applied to less than one-third of this acreage, or 600,000 acres.

In the Inland Empire western white pine is not only the most valuable timber species, but it is one of the more abundant and easier species to propagate. The forest industry there has been dependent upon its production as a major species to insure its security and stability. On the other hand, while sugar pine is presently the most valuable timber species in California, it is not one of the more abundant species, and the forest industry there is not dependent on it. Besides, it is the most difficult timber species there to propagate and manage. However, in spite of the great differences in the influence of these two species on the economy of their regions, and the differences in ease of propagating, identical economic considerations influence the great reductions in managed acreage in the two regions. This is principally the cost of blister rust control added to the other costs of managing for the production of quality white pine wood.

In both regions it is essential to grow enough premium-priced white pine on the protected acres to make the rust control efforts and costs economically worthwhile. There is little or no evidence in either region that the white pines are ecologically necessary to maintain forest cover. The justification for blister rust control is entirely economic.

In both regions control was originally started on more area than now is in control units. The reasons for this large-scale beginning were mainly two: One, because the costs of control were at first underestimated; and the other, because control was started before intensive management plans were made. It soon became evident that control costs over the long periods required to produce premium grades of lumber were going to be prohibitive in stands that would not produce a large percentage of the white pines. It was realized that it is not feasible to grow white pines on every white pine acre. Stands had to be chosen that were well stocked with white pine. Some control experiences showed that even some of these well-stocked stands could not economically be managed unless they made up a large percentage of individual drainages. Thus, it became necessary to select those drainages which would give the best combination of cost per unit, and quantity and time of yield. It meant managing the drainages, cutting, and otherwise handling the stands to produce the maximum volume of white pine.

At first, control was an independent protection job. But managers and economists soon realized that plans and programs for control should be completely and tightly coordinated with other management plans, and vice versa. It must be a "white pine project" in place of a "blister rust control project". Blister rust control should be one phase of the work--along with burning, planting, weeding, fire control, and other measures required to grow white pine at low cost per thousand board-feet. It was realized that good intensive white pine management involves much more than good management in an ordinary sense. A landowner could protect his forest from fire and cut it in such a way as to insure high yields, but unless he goes much farther than that, he will not have much white pine in his future crops. Without stand improvement and species manipulation the benefits normally resulting from blister rust control will not be completely realized.

Another important factor in reducing the acreage of managed white pines is the continuing increase in value of associated tree species. These value increases have been brought on by acceptance of other species in the lumber trade, and by the great expansion of the pulp, chipboard, and other fiber-using industries. Some forest managers doubt that blister rust control is good business, when stands of other tree species may be managed at much less cost. Economists and forest managers both have carefully analyzed the soundness of white pine management ventures. Both have concluded that the white pines will continue to occupy preferential positions in the lumber market, and under certain conditions intensive management involving blister rust control is economically and otherwise sound business.

It should be noted that in both the sugar pine regions and the Inland Empire many of the white pine areas are publicly owned and managed. This aspect of ownership has accounted for a large percentage of the

white pine management units. Of course the national parks have incentives other than economic to justify blister rust control. But national forest managers have fewer of these other incentives, and their decision to establish a control unit is largely economic. The public managers are more willing to take the long-time view on investments and returns from them. They are not so much influenced by immediate profits and minimum long-time investments.

In the present sugar pine stands, even the old growth cuts out less than 40 percent of premium quality lumber. The rest is common grades that could be replaced by ponderosa pine commons. The old-growth stands of sugar pine will be cut out soon after the turn of the next century. The perpetuation of sugar pine is a costly and uncertain venture at best. Regeneration is difficult. The climate is often adverse; competing brush and other tree species are deterrents; and rodent and bird activities are hazards. Adequate cone crops occur in only 1 out of 5 years, and then the heavy seeds effectively seed only to a distance within 100 feet of a seed tree. Cone crops in some years are almost entirely destroyed by rodents, birds, and cone insects. Seed viability and germination are usually low, and seedling survival is poor. Slash disposal, seedbed preparation, and brush removal are costly but necessary to get good natural regeneration. In Unit Area Control, the best silvicultural means of getting natural regeneration, cutting must be planned during heavy seed years or planting becomes necessary. Even planting survival is often poor, and freezing injury to planted seedlings is common. These aspects of sugar pine management alone discourage many private managers. When blister rust control is an added cost it is easy to understand the reluctance of some timber companies to manage their stands for sugar pine, even on the better sugar pine sites.

Objectives of blister rust control are in harmony with other timber management objectives. Both are best served by keeping the land fully occupied by growing timber. The more timber the less ribes, and the greater the yield of pine per acre the less the cost of ribes control per thousand feet. But timber management practices alone cannot adequately control blister rust. The basic strategy in ribes suppression is to exhaust the stored seed supply and eradicate existing ribes. The problem is not to keep out blister rust, but to continue to grow pine in spite of the rust. It is neither practical nor necessary to eliminate the disease entirely. Cutting methods can materially aid or impede primarily through their effects on ribes establishment and development. Frequent cutting or other silvicultural activity disturbs the soil and opens the stand, and thereby increases both the difficulty and costs of ribes eradication.

In the sugar pine region, cutting practice for many years was to make light initial cuts of unthrifty trees, with the objective of covering the old-growth stands as rapidly as possible so as to utilize the trees that would die if logging were delayed. Second cuttings were to follow in less than 30 years to open new areas for seeding, and to release established seedlings, and to harvest

any additional trees that appeared likely to die. This type of cutting in the mixed-conifer forests offers little chance for heavy ribes populations because of the shade-intolerance of the ribes species that occur there. However, this type of management eventually excludes sugar pine from the stand. The true firs and incense-cedar, because of their tolerance to shade, replace the sugar pine that is cut. If good stocking by sugar pine and other coniferous regeneration would follow heavy cuts of virgin sugar pine, the ribes seedlings developed after cutting could be controlled rather easily and promptly by eradication and suppression. However, after such cutting, good reproduction has been unusual. The mixed-age forests of the region likewise preclude the clear-cut, burn-and-plant sequence used in the Inland Empire white pine region as a successful silvicultural method of blister rust control and pine management.

The Unit Area Control is probably the best silvicultural method yet devised for combining both blister rust control and natural regeneration of sugar pine; but it must be planned for regeneration-cutting during heavy seed years--otherwise planting becomes necessary. Because of the many difficulties and uncertainties of getting sugar pine reproduction, most units selected for management of sugar pine have sugar pine reproduction already established. In such units canker removal, weeding, and thinning are desirable when blister rust is already present in young stands. Because of the numerous associated tree species in most young sugar pine stands, release of potential sugar pine crop trees is usually required at least once and probably twice during a rotation. The crop trees are often pruned, both as a blister rust control measure, and to provide knot-free wood in the lower bole. In present sugar pine management areas the principal replacement species are white and red firs and incense-cedar. Ponderosa pine replaces only 5 percent of the sugar pine. Intensive sugar pine management, then, includes both blister rust control and stand improvement measures. In estimating additional returns from such management only the expected yield from crop and potential crop trees, not the entire sugar pine component of the stand, is considered.

Although the young-growth sugar pine resource plays an important part in the region's forest economy, it is not of primary concern. The basis for the selection of units to be managed for sugar pine is primarily the economic consideration of the stand or stands within the unit. To simplify the determination of the economic rating of a stand, Dr. Henry J. Vaux, of the University of California, has prepared tables that incorporate all the cost and return factors. To apply these tables for evaluating a young-growth stand, the forest manager starts with a cruise, in which sugar pine crop and potential crop trees are tallied by 2-inch size classes, and the site index of the stand. The summary of the number of crop and potential crop trees, by size class, combined with blister rust control costs per acre, determines the economic rating. Although the decision to select a unit is based primarily on this economic rating, there are other factors that need to be considered, such as the most effective and efficient blister rust control methods; the over-all management requirements for the entire ownership or working circle; and the most effective administrative plan regarding protection and stand improvement.

In the Inland Empire, forest management in western white pine is largely dictated by white pine blister rust. As with sugar pine, only by correlating blister rust control and forest management practices can western white pine be grown on sound economic basis. Control and management practices must be harmonized in order to take full advantage of every natural aid that is practicable, and managers must have a thorough knowledge of ribes ecology and rust behavior as well as western white pine management. Blister rust control is achieved primarily through the suppression of ribes. Here pruning out pine infections is only a minor and temporary aid to control.

The development of rust-resistant white pines may in time change the management picture somewhat. But the necessity still remains for protecting existing stands upon which the industry will be dependent for another century.

The improvement of herbicidal sprays and spraying methods has allowed more versatility in cutting methods in recent years. However, the fact remains that cutting and harvesting methods affect ribes by changing the density of the forest canopy, by the mechanical disturbance of the soil in logging, and by fire in the disposal of slash. Experience has shown that light cuttings, which result in not more than 20 to 30 percent of full sunlight reaching the ground, do not permit an appreciable development of permanent ribes population. Such cuttings in well-stocked stands may remove up to 30 percent of the board-foot volume. Although some ribes seeds germinate following this type of cutting, mortality of resulting ribes seedlings is high, survivors develop slowly, and the amount of ribes seed they produce is insignificant. As the canopy again closes, these ribes are gradually suppressed. Resulting blister rust damage from such meager ribes population usually is small and is largely confined to the smaller trees. Thus these lighter cuttings materially assist in reducing future ribes populations and the ultimate cost of ribes suppression. Repeated light cuttings will largely exhaust the stored ribes seeds, so that when the final harvest cut is made ribes population will be small.

If moderate cuttings are made, the supply of ribes seed may be similarly exhausted at a more rapid rate. However, in such cuttings there will be some openings where ribes can become established, and direct ribes eradication will be required. Moderate partial cuttings permit coniferous reproduction, and because of the great amount of shade, the more tolerant species are favored. This means that when the overwood is removed, weeding of the young stand will be required to produce a new forest that is predominantly western white pine.

Partial cutting of either light or moderate intensity is particularly important, because it allows the forest manager to delay blister rust control for 20 to 30 years, at which time he may have a better basis for deciding whether he wants to perpetuate western white pine or convert to other tree species.

Many past heavy cuttings in western white pine in the Inland Empire have been abandoned to the rust because the resulting ribes populations preclude economically feasible control. However, recent development of

hormone herbicidal sprays has given promise of a brighter future for such cuttings, especially since the development of truck-mounted sprayers to broadcast the low-cost herbicides. Heavy cuttings of the seed-tree type where an adequate source of western white pine seed is left could become more useful if the new sprays and techniques are successful.

Clear cutting in mature and overmature western white pine stands is necessary if the stands have such low vigor that partial cutting is not satisfactory. In such stands all merchantable material should be removed and the area broadcast burned. After the ribes seeds present have germinated, all remaining trees and snags should be felled and the area reburned. This ribes seed germination is largely completed in 3 years. Any subsequently developed ribes plants should be eradicated before they produce a new seed crop and before the area is planted. The lack of sufficient fuel and the high-hazard burning conditions required for a second burn have made this two-burn method unpopular in recent years.

Sometimes, because of unusual conditions, areas treated by the double-burn method may still support large ribes populations. In such areas broadcast spraying of a herbicide may be the more economical method of eradicating the ribes before planting. On clear-cut areas where burning is not possible or practical, the broadcast spraying method of ribes eradication should be considered.

In the Inland Empire, forest managers have stressed the importance of integrated management action. They have determined that western white pine management is best accomplished in working units rather than on the individual stand basis. They define a working unit as follows:

"A working unit is a subdivision of the white pine zone which requires blister rust control and management as a unit. It is composed of one or a group of stands so situated topographically that the presence of ribes outside the boundaries of the working unit has a minimum effect on the white pine within the unit, and the benefits of ribes eradication within the unit are largely confined to it. It may be said that a working unit is that subdivision of the white pine zone that can be advantageously managed as a unit for the production of white pine at least cost under the handicap of blister rust. A working unit often will consist of a single minor drainage."

The number of units in the western white pine region depends largely upon ownership and upon costs of blister rust control, as it does in the sugar pine region. If costs can be reduced, more units can be added. Units have been assigned priority rankings for possible inclusion. Within a unit the forest manager has the responsibility of selecting and using practices and silvicultural means that will produce the greatest amount of western white pine at the least cost. And, as in the sugar pine country, the over-all management requirements of the entire ownership or working circle and the most effective administrative plan regarding protection and stand improvement must be considerations of the forest manager.

In both the Inland Empire and in the sugar pine region the future of white pine management depends on many things. Among them probably the most important is the continued preferential position of white pine wood in the lumber market. Although such things as greater efficiency and reduced costs of blister rust control, the rapid development of rust-resistant white pines, or the development of improved silviculture and management methods, could have unpredictable effects. The development, through our present microclimatic blister rust studies, of methods to identify low-hazard areas could change the picture in management of the white pines, as could biological ribes control or some other unforeseen development. But, no matter what the future improvements in management may bring, the fact remains that we will never have the area of white pines, under management or otherwise, that we have had in the past.

UNDERGRADUATE TRAINING IN FOREST PATHOLOGY

C. W. Waters

It is with some degree of reluctance that I undertake my task of discussing Forest Pathology in the undergraduate curricula of the Schools of Forestry. A considerable part of my reluctance stems from the fact that for 30 years I have been so closely associated with the problem that I may well have lost my sense of perspective and have been unable to perceive how much progress has been made in the Schools of Forestry in stimulating a working interest in the subject and an appreciation of its importance to the field of forestry. This feeling may be accentuated by the fact that recently I unearthed a rather faded manuscript which I once read before the Forestry Section of the Northwest Science Association, a quarter of a century ago, on the role that Forest Pathology should play in the Schools of Forestry. In it I discussed, with all the fervor of youth, not only the importance of, but the necessity for a proper understanding of the principles underlying tree diseases by all graduates of our Schools of Forestry. I recounted the need for greater stress to be given to the subject in the undergraduate curricula; the absence, as I saw it, of an adequate appreciation of its importance by the practicing forester, as well as by the administrators and faculties of the schools. It was suggested that every forestry school graduate should have had a course in Forest Pathology; that it should be the ultimate aim of every teacher and worker in the field of pathology to make the forester disease conscious and to "demonstrate that forest tree diseases can and should be controlled". Further, that Forest Pathology was as much an integral part of forestry management as Silvics, Mensuration, etc.

The reaction to my fervent and almost at times, I fear, fiery "voice in the wilderness" was somewhat mixed. Expressions of amusement, tolerance, surprise, impatience and sympathetic agreement created an interesting mosaic on the faces of my listeners. No serious disagreement resulted; no one denied me my right of expression -- in fact no one said much of anything! The silence was broken by the announcement of the next paper and the meeting proceeded in an orderly manner. My big moment had come and gone. Using a phrase not yet in existence at that time, apparently I had "goofed". A conflict of mixed emotions, relief and disappointment, waged in my soul. Relief, that I had not been squelched by the grey heads present; disappointment that I had not properly impressed them. Both emotions struggled for dominance and it appeared to be about a dead heat. Of one thing I was convinced, Forest Pathology had not been sold to those foresters. Today, after a quarter of a century of preaching the gospel to well over 2,000 embryonic foresters in Pathology and cognate courses, many of whom occupy positions similar to those who comprised my earlier audience, I cannot help but wonder if a similar speech would arouse the same enthusiasm among them. This would indeed be a test of the efficacy of my methods.

In a letter recently received from a fellow teacher in Forest Pathology, he states as one of the aims which he hopes to achieve in his course -- "to emphasize to the student that the pathologist can do something about diseases -- their prevention and control". What a familiar ring to those words of

hope and optimism; it seemed almost as if I, myself, had once used them! The vigor with which my colleague underscored and capitalized the words even though he predates me by several years, emphasizes the persistent fortitude and zeal possessed by at least one member of our teaching fraternity.

Teaching Forest Pathology has been a pleasant experience. I have never felt that the good student was completely bored with the course. A few have even become interested enough to make it their life work. More would probably have done so had the odds not appeared too great against securing a job.

Assuming that my experience is common to most teachers in this field, we can safely say that the teacher of Pathology has a receptive group of students with which to work.

The first question I should like to ask, and I am going to borrow one that was raised at a conference of teachers of Forest Pathology and practicing foresters at Atlanta in 1955, "Are the graduates of our schools of forestry adequately prepared to cope with and understand problems in forest pathology when these are encountered in the field?" If this question could be given an unqualified answer in the affirmative, then the content of our courses and the methodology employed by us would be vindicated; there would be no problem and we would be here today solely for the purpose of patting ourselves on the back and presenting each other with flowery kudos.

Because I know that my colleagues on this panel will get down to brass tacks and seriously attempt to offer a constructive plan of action, I should like to deviate a bit and consider some of the factors as I see them which makes the task rather difficult. At the risk of appearing to dodge the real question and to be unwilling to exchange ideas as to the best methods and materials to employ in such a course, I should like to discuss Forest Pathology in its context, the Forestry School Curriculum.

If Forest Pathology is to be of the greatest value to the forester as a workable tool, it should be integrated with forest principles and practice.

According to data compiled at the Atlanta Conference, in only 8 out of 35 institutions is Pathology presented in the Forestry School. Only a little over half of the teachers of Forest Pathology indicated this field as the one in which their major training and research lay. This practice, it seems to me, does not allow for much integration which probably should be the soul of and excuse for the course. It is true that valuable principles underlying the whole field of disease can be taught without integration but it cannot be as effective.

It was agreed at the Conference that there are not enough trained forest pathologists to fill the needs in all the institutions in which the subject is taught. This, it seems to me, raises a peculiar point of interest which is almost an anomaly. For the results of a brief survey made of a few of the leading Schools of Forestry in the United States, I came to the conclusion that there were probably not enough full-time

teaching positions in Forest Pathology open in the country to make the field attractive to prospective teachers in this field.

One school offers Forest Pathology as an alternate elective to Plant Taxonomy. Two schools present it as a part of a one-quarter survey course involving all forest damage. At another, students may elect two out of a panel of three courses, Pathology, Entomology and Wild Life.

If this is typical of the remaining schools it would appear on the surface, at least, that some Schools of Forestry do not consider the teaching of Forest Pathology of sufficient moment to warrant placing it on a par with other forestry courses, and making of it a full-time field of endeavor. During my sojourn in the School of Forestry, I had charge of the courses in Silviculture, Dendrology and Wood Technology in the School of Forestry, while teaching the course in Forest Pathology in the Department of Botany.

Frankly, I find myself not nearly so concerned with what shall be included in the course, or how it shall be presented, as I am with the ineffectual role it seems to play in the education of the undergraduate forester.

I have tried conscientiously to vary the method and the philosophy of the course. One year the fundamental background might be stressed and more time spent on life histories and taxonomy of the pathogenes. Another, I might present the course from an ecological or silvicultural basis and attempt more integration with forest problems. With either method, it seemed to me that by the time the student was ready for graduation, he was so snowed under with management plans, road building, cruising, etc., that pathological rotations, high-risk trees, root rots and needle blights remained but dim memories of an almost forgotten past.

I cannot help feeling that although the ideal undergraduate course might be one that is completely integrated and taught by a well-trained Forest Pathologist, any course having a pathological slant that is well taught by a good teacher, whether he be a Mycologist, Bacteriologist, or Plant Pathologist, cannot help but strengthen the forestry student in those biological fundamentals in which he is glaringly deficient.

Until rather recently, students came into my course in their Junior year with one year of General Botany, plus Plant Physiology and Ecology. It was possible to give them what I considered an average-to-good course. Today, this preparation has been reduced by almost a third. As a result, I am obliged to spend considerable time merely introducing them to the fungi and making up the deficiencies in their preparation. I feel that the quality and utility of the course has been greatly impaired.

The picture seems confusing. At a time when it appears that the practicing forester is becoming more biologically minded and is showing an increasing appreciation of the tremendous impact which disease and insects have upon forest growth and yield, it seems to me that our students in the Schools of Forestry are becoming increasingly technologically minded. In addition to the seeming apathy displayed in some schools at least, the condition is

aggravated by misapplied good intentions on the part of the general faculties of some of the universities on whose campuses professional schools are located.

In the case of one school with which I am familiar, certain group requirements were set up by the University faculty, encompassing the broad fields of the Humanities, Philosophy and Science. Each student is required, in addition to his major, to take a certain number of courses from each of the three fields. This is a laudable endeavor but it has backfired in the case of Forestry.

To make room for such courses in an already jam-packed curriculum, drastic cuts were made by the forestry school in the background courses in Biology and related fields. General Botany, Plant Ecology, Zoology, Geology, Entomology, and Physics either were reduced in credit number or actually deleted. In one curriculum, Forest Management, room was discovered for such additions as Trade and Technical Journalism, Aerial Photo Interpretation, Industrial Psychology (this in addition to a general psychology course), Sawmilling and Lumbering, Seasoning and Preservation, Meteorology Elements of Forest Protection (although fire protection and forest pathology are still retained), Watershed Management and a two-credit Sophomore course in Field Mensuration, in addition to the eight-credit course already being given in this field. If trends such as these continue, it would appear that the forest manager of the future will be conversant with all of the accessories pertaining to his profession, but will be sadly deficient in a working knowledge of the actual "piece de resistance", in this case the living tree. What sort of a structure of Forest Pathology, whether it be a three-, four-, or even a five-hour course can be superimposed upon such a foundation?

When the impending wave of outer space and satellite hysteria engulfs us, and the intellectual cream of our youth, aided perhaps by government subsidy, is stampeded into the physical sciences, forestry, as well as all other fields of the biological sciences will have to present a much greater challenge than anything heretofore shown. Intrigued by unearthly gadgets in a field of superlatives, root hairs and root rots, mycorrhizas and mistletoes will offer very poor competition, and will be crowded farther and farther, I fear, into the limbo either of the unknown or forgotten. At a critical period when the emphasis in forestry should be shifted from that of harvesting to growing the crop, technology and mechanics will receive an added impetus.

Speaking as a long-time teacher of Forest Pathology, and of Silvics, Silviculture and Nursery Practice for almost as long, and as one who believes firmly that sound forest practice must be built on biological rather than so much on economic principles, the future does not appear too bright. There are bright spots, however, and they appear to lie not in undergraduate forestry education but in research and practice, and particularly in the field of private practice.

At a Seattle meeting of the Northwest Science Association a year ago, I made a tabulation of the papers and participating agencies in the Forestry Section. No papers on logging or fire were presented. The subjects covered were Ecology (one whole session), Soil and Site

Factors, Forest Regeneration and Management, and Diseases and Insects. Federal agencies contributed 33 percent of the program, with 8 papers; private industry followed with 7 papers and 26 percent; and the schools with 6 and 22 percent respectively. This, I think, is encouraging and spells out a decided trend.

Industry, it appears to me, is anxious to receive aid in solving its silvicultural and, hence, pathological problems. More and more forestry graduates are finding their life work in private industry as company foresters. The extent to which these emissaries of good forest practices will raise the general level in that direction will depend largely on the viewpoints and philosophy received at their respective Forestry Schools.

If as a Botanist, and hence somewhat of an outsider, I appear presumptuous in making free with the whole Forestry School curriculum, rather than confining my remarks to Pathology, it is because I believe they are inseparable and that Pathology cannot be removed and discussed outside of the context of Forest Management.

When we consider the long and painful course which human medicine has traversed from its inception in ignorance and superstition to the heights it has attained today, and the position it occupies as an inseparable and essential facet of human society, and when we observe how animal and plant pathology have become indispensable guideposts in the fields of animal and plant breeding, it is difficult to see how Forest Pathology and Forestry can be any different.

It seems rather unfortunate that we, as teachers of Forest Pathology, should be obliged to find ways and means of shaping our programs to fit so many varied conditions; courses carrying from 3 to 5 hours' credit, and ranging from those which are elective, alternate electives to required. This undoubtedly reflects the varying backgrounds of those responsible for setting up the curricula in the several schools.

I do not see at present how we can hope to set up minimum and uniform standards in Forest Pathology until the course is given a more uniform standard of recognition by the Schools of Forestry.

The stipulation by an accrediting agency that so many credits must be taken in Forest Protection still permits a wide latitude of choice at the local level.

Much more might be added to these pages of random impressions picked up over a period of many years of teaching in basic and applied Botanical fields. But such would merely continue to echo the beliefs of those who agree with me, and prove most convincingly to those who disagree that I claim far too much for the virtues and scope of Forest Pathology. As a certain forestry executive once exclaimed to me on looking into Baxter's "Pathology in Forest Practice", "Why don't you pathologists stick to your own field and let the silviculturists handle the forests?"

If my remarks have sounded cynical and pessimistic, be assured that such is not my intent. I believe that progress is being made; I feel that in the field of Forest Pathology substantial advancement has been made in research.

Dependable working knowledge is waiting, I believe, for the Silviculturist and Forest Manager. Whether they are availing themselves of this information and incorporating it into their management plans, I do not know. That is beyond the scope of my remarks. I do feel, however, that Forest Pathology does not occupy its rightful place in the curricula of our Schools of Forestry. As a result, I am convinced that not enough of our forestry graduates leave the doors of their Alma Maters with sufficient knowledge of the field to equip them for the important and necessary role that Forest Pathology should and eventually must occupy in the proper management of our forests.

GRADUATE TRAINING IN FOREST PATHOLOGY

J. E. Bier

The Conference may approve generally a statement to the effect that there is an urgent need for greater opportunities for training in forest pathology at the graduate level. The type of training a graduate student in forest pathology should receive, and the research disciplines emphasized, may be a more controversial subject, and I would prefer to discuss the problem in this direction.

During my graduate training, and I feel the same may apply to others, primary emphasis was given to forest mycology, and I was frequently referred to as a forest mycologist as being synonymous with a forest pathologist. My primary need was training and experience in the observation and identification of organisms occurring on living trees, slash, forest products, etc. After several years of concentrated effort in this direction it was not difficult for me to rationalize and investigate tree disease problems solely on the bases of the occurrence and frequency of host-organism associations, the host-organism association in itself being the primary factor for consideration. In more recent years I have heard the statement made on several occasions that the pathologist's first approach to a disease problem should consist in discovering the organism which is the primary cause of the trouble.

The theme topic for the El Paso meeting was "Ecology in Relation to Tree Disease Research". In my contribution to the meeting, I endeavored to illustrate that undue emphasis on host-organism associations in many disease problems may lead to negative or misleading interpretations rather than into a proper understanding or practical solution of important tree disease problems. An effort was made to demonstrate that in some disease problems the host-organism associations in themselves were simply indications of the real problems. An effective approach and solution to these problems required primary consideration to one or more of the following research disciplines in addition to problems related to forest mycology: genetics, environmental and soil influences, and tree anatomy and physiology. It would seem, therefore, that to be effective the forest

pathologist requires training in, and appreciation of the importance of all the basic factors which may influence tree growth, disease susceptibility and survival.

There would appear to be general agreement that the age of specialization in forest research is here to stay and is a necessary development. However, in my opinion, it may be argued whether or not specialization in some instances has not overruled common sense. May it not be possible for a forest researcher to endeavor to prove the impossible, and feel justified in doing so, provided he makes a sincere effort within his field of specialization? Meetings have been attended on a number of the more complex disease problems where it would appear that forest pathologists have deliberately avoided a straightforward approach to problems for the reason that the research involved might include studies believed to be outside of the field of forest pathology in the forest mycology sense. I am convinced that the training of the forest pathologist should be such that he will have the confidence to enter into the preliminary aspects of any basic science which may be important in solving his disease or host-organism problems. Should these preliminary studies appear promising, other specialists could be invited to enter into the research, having the assurance of helpful background knowledge.

In view of what has been stated I believe that the graduate student in forest pathology should be able to major in any of the following basic sciences as related to tree disease research:

- (1) Genetics
- (2) Ecology
 - Climatic influences
 - Soil influences
- (3) Tree Anatomy
- (4) Tree Physiology (Plant)
- (5) Taxonomic and Experimental Mycology
- (6) Biometrics

WHAT GRADUATE WORK IN FOREST PATHOLOGY SHOULD INCLUDE
TO PRODUCE A WELL-TRAINED MAN

T. S. Buchanan

It is obvious to me now that after agreeing to discuss two subjects at this conference I made the mistake of preparing for the wrong one first. Having taught forest pathology, having worked for several years in forest pathology research, and having now had just a little experience in forest pathology research administration, I thought that this would be an easy subject for me to cover. Then I looked back at the list of proposed manpower requirements given in my earlier talk, noted the wide range of disciplines we had indicated as being necessary to adequately cover our field, and realized this was no simple assignment after all.

I can see no way to approach this subject other than to start at the very bottom and first define a few terms. I trust these following definitions, which I used as a teacher and which I still consider to be perfectly valid, will also be found acceptable by the members of this work conference:

Health - soundness of body and vigor of normal activities.

Disease - the inhibition or other disturbance of one or more of the physiological activities of an organism.

Tree pathology - the science of abnormal tree physiology, or tree disease, including the deterioration of the dead tree or its dead parts, or decay.

Forest pathology - the application of tree pathology to the practices of forest management.

Just to make sure I do not too narrowly limit our field of activity, I'll include just one more definition:

Wood products pathology - which is concerned with the deterioration and decay of manufactured wood products in the process of manufacture, in storage, and in use, and the prevention or correction of deterioration and decay.

If we accept these definitions, then it follows that a Forest Pathologist is one versed in and responsible for the application of tree pathology to the practices of forest management. This in turn implies the Forest Pathologist must be able to recognize disease when he sees it and, since disease is merely deviation from normal health, he must also be familiar with the inner workings of a healthy tree.

Actually then, the forest pathologist has as his domain the determination of the whys and wherefores of any significant deviation from normal tree physiology. This appears to be a mighty big territory to cover when we realize that various biotic, climatic, and edaphic factors can all induce

abnormal tree physiology. Fortunately the abnormal physiology directly induced by the myriads of insects attacking forest trees has been removed as one of our problems and placed in the lap of the Entomologist. Fortunately, too, the direct effect of fire has also been assigned as a responsibility of others.

Excluding the direct effects of insects and fires, every other agency or condition resulting in abnormal tree physiology is by definition of interest to and the responsibility of the Forest Pathologist. This is not only true by definition but true also in actual practice. Anything wrong with a tree that isn't obviously the direct effect of fire or definitely ascribable to insects, is relegated to the pathologist.

Fifty years of forest disease research in this country has amply demonstrated that the following biotic and abiotic agencies are capable of inducing forest tree diseases:

bacteria	animals
	(definitely including man)
fungi	
	certain flowering plants
viruses	
	unfavorable climatic factors
nematodes	(temperature, moisture, aeration, light)
	unfavorable edaphic factors
	(nutrients and toxins)

At first glance this doesn't appear to be a particularly impressive list of possible causal agents but when we start breaking each of these headings down into the hundreds of possible subdivisions we find we actually have thousands of causes of forest tree diseases. We not only have thousands of possible causes of tree diseases, but we have hundreds of important forest tree species susceptible to one or more of these diseases. These susceptible trees range all the way from tiny seedlings and even the fruits and seeds themselves, to giant forest veterans, growing in all conceivable intermixtures of species, ranging over an entire continent, from sea level to timberline, and in association with all other lesser forest vegetation and animal life.

To make the situation even more complex, the factors causing disease more frequently than not team up in their efforts to destroy a tree. Sometimes they work simultaneously, sometimes one sets the stage for another, and always the biotic agents of disease are influenced by environmental factors. Even insects and fires again rear their ugly heads, for they often are the factors responsible for just enough imbalance in a tree's normal physiology to allow some generally less aggressive pathogen to take over and finish the job.

Now, how in the world to train a man - even at the graduate level - to be fully competent in the disciplines he might find useful to him in research on forest tree diseases? We could, I guess, thumb through various college catalogs and check off each course it would be desirable for him to take. This list would be so lengthy, though, that by the time our candidate had

completed all the courses he would be too old and feeble to be of much use to us in the field. Then, too, our candidate would have to be something of a Superman in order to absorb all of this academic training. But let's assume he could do it, and rapidly enough to complete it all while young enough to still get around in the woods. There is still the possibility, maybe a pretty strong possibility, that he'd have so many facts in his head he'd be unable to straighten them out and get them so organized as to put any of them to effective use in solving a forest disease problem.

What I'm trying to get across here is that appropriate graduate training for work in forest pathology has to be more than the taking of a certain large number of required and specified courses! The candidate must also be imbued with a certain attitude and philosophy toward life and his chosen life's work that is impossible to define but which I'm sure we can all recognize when present. These are things rather difficult, if not impossible, to impart through formalized classroom presentation. They are, instead, subtly conveyed to the candidate through the spirit, interest, and enthusiasm for his chosen field constantly displayed by his teacher and by his supervisors on the job. This, as well as the more formal phase of training, is more readily accomplished if a high degree of discernment is exercised early in the game when first considering candidates to be admitted for graduate training.

From our titles - Forest Pathologists - it is implied that we are not purebred stock but inter-specific hybrids, half forester and half pathologist. In actual practice we employ, and find it desirable to do so, not only foresters, pathologists, and hybrids, but specialists in other lines who literally do not know one tree from the next when they first appear on the job. Generally speaking, however, in the past and even up to the present time, those persons engaged in forest pathology research have been either undergraduate Foresters with some plant pathology superimposed in graduate school or undergraduate Plant Pathologists with some graduate training in forestry added as a frosting. Which of these varied backgrounds makes for the most capable and useful Research Forest Pathologist? I say it makes no material difference - so long as the candidate is possessed of a keen and inquiring mind and those other hard-to-define attributes I tried to point out in the preceding paragraph.

But, so long as there are candidates seeking higher degrees and aspiring to make their name in the field of forest pathology, they are going to have to take some formal course work. The question then arises as to which few of the multitudes possible and desirable shall they take since we've already decided no student could possibly either ingest or digest them all. Before making this decision it should be emphasized that successful completion of any formal course merely provides the individual with facility (or at least familiarity) with one additional tool to aid him in practicing his trade. I'm sure we all know plenty of people adept with hammer and saw that we would never consider hiring to design and build us a house.

I think the graduate student in forest pathology has to decide (or be directed) at the very outset which of two alternative routes to follow:

1. Take introductory or exploratory courses in as many of the supporting disciplines as he can and gain a working knowledge of the entire field, or
2. Specialize in one particular facet of the problem, become highly skilled therein, and be content with only an appreciation of the over-all field.

It is hoped that about half the graduate students will choose one route and that the rest will choose to follow the other path. We need specialists, and highly trained specialists, in each of the various sciences basic and essential to research in Forest Pathology. We also need men so trained as to recognize the broad problem areas, to give adequate direction to the over-all program of work and to coordinate and integrate the efforts of the specialists. The first route might more logically lead eventually to considerable administrative responsibilities. The second would be more suitable for one interested primarily in devoting his undivided attention to research and to becoming a subject-matter specialist. The choice would depend upon the interests and aptitudes of the student and the decision reached at this point will largely determine the specific selection of formal courses for study.

There are, it seems to me, a few basic talents required which ever way our prospective Forest Pathologist chooses or is directed to go. He must be able effectively to communicate with his fellow scientists and fellow men. Only three methods of accomplishing this are in general use throughout the civilized world today -- reading, speaking, and writing. Many undergraduate "scientists" balk at courses intended to improve their facility along these lines. Because they do balk as undergraduates is often the very reason necessitating their having to have added doses of training as graduate students. Accuracy and thoroughness are also essential talents, for deficiency here may lead to loss of faith in, or even refusal to accept the results of one's research efforts. Courses in the field of mathematics offer valuable training in these areas and, of course, can at the same time lead to proficiency with another specific and useful tool: namely, Statistics.

Our budding Forest Pathologist must also be able to "get along with" his cohorts and with his neighbors. I can well remember certain "odd ball" students (perhaps I was one of them) being advised to pursue some line of research (in contrast to management or administration) simply because they were recognized as "odd balls". It was felt they would do less harm or would be less obnoxious in a research position than anywhere else. But the day of the "long-hair" scientist working alone in his secluded laboratory is essentially a thing of the past. The team approach to research is pretty much the accepted pattern today and certainly the broad and varied problems in Forest Pathology are ideally suited for team attack. So, in many instances it may be desirable, even essential, that our graduate candidate be given added training in the Humanities, including even specific courses in Psychology.

Let's take time out here briefly and sum this all up. It is my feeling that we must first exercise keen judgment in initially selecting

our graduate candidate; that we must next attempt to develop the whole man; and then, finally, we can concentrate on training a Forest Pathologist.

It must be assumed that our candidate for graduate study in Forest Pathology has had adequate undergraduate training in the basic physical, biological, and related sciences and arts. As aids in determining the specific technical courses for him to take as a graduate student, I would again refer you to my original definitions of Health, Disease, Tree Pathology, and Forest Pathology and to the listing of the broad categories of agencies known to cause tree diseases.

Plant Physiology and Tree Physiology courses are almost a "must" for the graduate student, for pathology is but the science of abnormal tree physiology. How can one recognize and appreciate the abnormal unless he is fully competent to recognize and understand the normal? A good background in Organic Chemistry and Biochemistry is essential for competence in physiology as well as for certain aspects of disease control.

Since Forest Pathology is the application of Tree Pathology to the practices of forest management it is essential that our candidate be familiar with the interrelations of plant communities. Plant Ecology, Climatology, Silvics, and Silviculture must then be added to the list of courses in which advanced training is highly desirable. Fundamental to these courses, and to Physiology as well, is a knowledge of Forest Soils, for it is from the soil and from the soil alone, that our tree, healthy or diseased, draws its water and mineral nutrients.

The Forest Pathologist-to-be must also be able to recognize and classify the various possible causal agents of disease. Courses in the taxonomy of the fungi must, therefore, be added to our growing list of requirements. Somewhere, too, he should gain at least passing familiarity with bacteria, viruses, nematodes, and certain groups of higher plants, for they, too, sometimes cause disease. We must even include some taxonomic study of insects for, even though their direct harmful effects are not a responsibility of the Forest Pathologist, he must be able to recognize them for they often serve as vectors for disease and otherwise influence the development of disease. I would emphasize here, however, that a skilled Taxonomist may fall far short of being a skilled Pathologist for a causal agent is but one of a complex of factors working together to induce disease.

This knowledge acquired in Physiology, Ecology, Soils, and Taxonomy can best be coordinated and developed into usable form through good courses in the fundamentals, techniques, and principles of Plant Pathology - including with certainty consideration of the various principles and practices of disease control. These are the courses wherein the pieces of the jigsaw puzzle - Causal Agents, Hosts, and Environment - fall together to produce the over-all picture we know as DISEASE.

This same background may well, with a little substitution, suffice for the graduate student planning to work in the field of Wood Products Pathology. Here I would suggest added emphasis on Chemistry, Physics, and Wood Anatomy at the expense, if need be, of Ecology, Climatology, and Silviculture.

What I have attempted to chart here very roughly is a course to be followed by the graduate student planning to become a general Forest Pathologist. The student aspiring to specialize would need essentially the same attributes and background training but would veer off this charted course a bit in the selection of special subject matter to be studied. The specialist could take any one or combination of the specific areas of study suggested above and by expansion and intensification thereof make of himself a very useful member of a forest pathology research team. He could even widen the range a bit and become a Photogrammetrist, Biometrician, Geneticist, or Radiologist and still be trained in a field of direct or supplemental importance in solving certain forest disease problems.

We still have left to consider the matter of an acceptable thesis or dissertation. Most universities require a thesis for the Master's degree and all require a Doctorate dissertation. These requirements serve a very useful purpose but I think we must appreciate, and be sure our degree candidate appreciates, just what that purpose is. In contrast to a research project assignment out on the job, I do not believe total emphasis should be placed on the attainment of results yielding concrete, specific, and new information. Rather, the thesis or dissertation should be looked upon as a final examination. Not as a final exam on factual matter in hand but one to demonstrate the candidate's ability to do original thinking; to plan, organize, and conduct in a logical manner a research project with a minimum of outside direction; to properly utilize the facts and techniques he has learned; to accurately make and record his measurements and observations; to logically interpret; and to clearly, concisely, and coherently present his findings. Whether or not he makes any "earth shaking" discoveries would seem to me to be beside the point.

Now some students hesitate to specialize in the field of Forest Pathology at the graduate level for fear of limiting themselves in employment opportunities. Personally, I think this fear is unfounded, in case of either the generalized or specialized approach. If our student possesses those desirable attributes and the background training we considered earlier, and if he succeeds in his course of graduate study, he will be so well rounded and well trained that he can qualify for employment in many other areas where knowledge of the biological sciences is a prerequisite.

Even today the Forest Service has vacant positions in Forest Disease Research--positions that are vacant simply because we have been unable to locate candidates whom we feel meet the desired standards. If and when our expansion plans are implemented, many more positions will be available and we hope that by then the graduate schools will have well-trained candidates waiting for us.

The report by Kaufert and Cummings for the Society of American Foresters on "Forestry and Related Research in North America" shows that in the field of Forest Pathology a higher percentage of the personnel employed hold advanced degrees than in any other field of Forestry or related research. This is not because of any "high brow" attitude on the part of employers of forest pathologists, but simply the result of the fact, as I've tried to indicate above, that the field is so broad and so complex that one cannot encompass it without going beyond the undergraduate level. It is for this reason, too, that the Forest Service would like to continue its recruitment for employment in Forest Disease Research with the Master's degree as the minimum educational requirement. On-the-job training will then take over perpetually to continue the educational process and ever increase the abilities and usefulness of our Forest Pathologists.

FOREST PATHOLOGY EDUCATION: IN-SERVICE TRAINING

James L. Mielke

Most forestry school students spend four years in a college or university; relatively few continue on for another year. During this period of formal education one quarter or a semester, rarely more, is devoted to a required course in forest pathology. Some students may add a course in forest mycology. With this limited knowledge of tree diseases the graduate goes forth into the woods.

This forestry graduate may, in one way, be compared with the membership directory of a scientific organization. Even by the time this directory leaves the printing press it is no longer up to date simply because changes of various kinds are continually taking place within the membership. Likewise, the forestry school graduate cannot be quite up to date on forest pathology because research continues and new information has appeared in the literature since he took his final examination and last saw his textbook on tree diseases. Furthermore, like the directory mentioned above, this textbook that the student used was also partially out of date before the printer's ink was dry on it. To cite an actual case, I assisted Dr. J. S. Boyce at Yale University with the galley proof of the final chapter in the first edition of his forest pathology textbook. At that time he showed me a sizable stack of index cards on current tree disease literature that had been published after the final draft of the manuscript had gone to the printers.

Should the forester on the job keep up to date, by one means or another, with the literature on forest tree diseases? Are the diseases of sufficient importance to justify that some of his time be spent on them? These two questions are amply answered in the affirmative in the 1955 draft of the U. S. Forest Service TIMBER RESOURCE REVIEW. Therein, under "Forest Protection Against Destructive Agencies", the combined growth loss and mortality caused by disease are reported to greatly exceed that caused by either fire or insects. From the standpoints of forest protection and good business, therefore, evidently there is no question about the necessity of the on-the-job forester's reviewing pertinent information on tree diseases and keeping up to date with the new literature.

How is the practicing forester in an administrative position to keep up with the current published information on disease? How much of this information reaches his desk? In this country not all foresters subscribe to the Journal of Forestry wherein some of the papers on tree diseases are published. It is rare indeed to find a forester having such journals in his office as Mycologia, Review of Applied Mycology, Phytopathology, and Canadian Journal of Botany. Reprints of the papers from the various journals are almost always available, but usually these reprints receive rather limited distribution among foresters. Copies of Government bulletins and leaflets usually are widely distributed. Forest experiment station research notes and research papers are well distributed within the region in which they originate. However, to receive them regularly from other regions it is necessary that the individual have his name placed on the mailing lists and then annually renew his requests for

these publications. I have yet to meet a ranger or other forester assigned to timber management on a national forest who does this. Furthermore, I have been in very few ranger stations or supervisors' offices that had forest pathology textbooks and other disease literature in their bookcases. On the other hand, timber management manuals, fire manuals, and other forestry publications always are in evidence.

Does the forester read any of the disease literature that, through one source or another, is available to him? My experience shows that some do and some do not. This situation, however, does not exist because of a lack of interest, but because of a lack of time. The workload of the forester, and particularly the ranger, is heavy. After a long day in the field, or a day devoted to paper work in the office, he is in no condition either mentally or physically to settle down with a technical paper. However, if he is confronted with a particular and important disease problem he makes special effort to obtain information on it. Otherwise the summer's accumulation of technical papers piles up. When winter comes, with its load of routine paper work, these papers are often not read but are filed away for future reference. Thus, much of this technical information frequently becomes, probably unavoidably, embalmed in print. The greatest use made of this material is by the researcher, but he certainly is much in the minority numerically.

I am thoroughly convinced that the best solution to this problem lies in a systematic program of in-service training of foresters. This can be conducted at various levels and also both in the office and in the field. It is a regular procedure that supervisors meet annually for a week at the regional headquarters. At least a couple of hours of this time could be devoted to discussion of regional disease problems. Also, the results of current research could be reviewed. This should all be conducted under the guidance of a pathologist stationed in the region and familiar with the problems. I have never been in a region where this has been done.

Another annual meeting held in winter and lasting a week is that of the forest rangers at their supervisor's headquarters. Here again is an opportunity for the forest pathologist to spend a few hours with the group. To date, this has been done on only one national forest in Region 4. During these meetings literature is reviewed, local and other disease problems discussed, some specimens are displayed, and colored slides of various diseases shown.

Within the past year the Forest Service inaugurated a regional training program for its younger foresters. Groups of these men, via large special busses, travel over much of the region. Time is spent on various forestry problems, but to my knowledge no consideration is given to tree diseases. However, time should be provided in this program for the forest pathologist. Possibly it is under consideration for inclusion therein. I do not know.

Some disease problems are chiefly local in their occurrence. Foresters are necessarily and commonly transferred from one ranger district to another within a national forest, from one forest to another within a region, or to another region. In making these moves, diseases new to the individual may be encountered. In-service training is therefore necessary to aid

these transferred foresters in the recognition of those diseases that he is unfamiliar with. Annual disease training sessions of supervisors, rangers, and other forest personnel will fill a portion of this gap.

One important reason for the necessity of in-service training programs is to train foresters to recognize diseases. This is essential in the detection of disease outbreaks and their systematic and prompt reporting. Unless a disease is recognized, it may remain undetected and unreported for years. To cite a couple of examples: many of our conifer leaf diseases are passed by simply as winter injury; and, the Comandra blister rust in Region 4 was not recognized for a number of years because the evidence gathered through a windshield in passing was diagnosed simply as porcupine damage.

Fires are reported as soon as possible after they are discovered. Their importance is stressed to the forester, and fire training schools are held every summer. Through these schools, publicity, and other means, he is soon taught to become conscious of fires and as a result is constantly on the alert for any evidence of them. These same foresters, however, never receive this type of training in tree disease consciousness and detection, but there is no question of its necessity if the forester is going to be alert to disease. His assistance in detecting and reporting them is needed. A region is pretty well covered annually, by various means of travel, by the rangers and other forest personnel stationed within it. Consequently the particular region could receive good yearly coverage for disease detection. Forest pathologists, however are few in number and spread out very thin. One or two of them simply cannot annually survey an entire region and also carry on research.

The in-service training program should by no means be limited to the pathologist's participation in the annual meetings of forest personnel. My experience has taught me that unquestionably the most satisfactory training can be accomplished in the woods. It is there that the forest officer can be shown what to look for and where to look for it. Signs and symptoms can be pointed out and the trainee taught to recognize diseases that are passed by simply because he did not know what to look for. As one of many similar examples in this connection that I could relate, last summer a forest supervisor asked me to spend a day with him in the woods. He was anxious to see the Comandra blister rust first hand and thus be certain that he could recognize it without question. Some of the lodgepole pine stands that we visited had between 50 percent and 85 percent (estimated) of the trees infected. Dead and dying tops and branches were common. The supervisor had not only flown over these stands but had also driven by some of them. He knew something was wrong with the trees, but since he was unfamiliar with the fungus and its character of attack, he was unable to positively diagnose the cause of the damage. We both profited by spending the day together. I believe that the pathologist can accomplish the most in the least time possible by getting out into the woods with the forester. Considerable past experience has thoroughly convinced me of this.

Annually I receive from foresters, specimens of insects accompanying an inquiry as to what the particular disease is and the method for

its control. This is simply another example, if more are necessary, of the need for in-service training in tree diseases. It further illustrates, in my opinion, that we should all endeavor to work together at every opportunity. It is no longer possible, with so much new material appearing in print each year, for one to keep up in all the various fields of forestry that have a bearing on his work. To me it all boils down simply to this: a forester's training does not end when he graduates from school.

APPENDIX I

Active Projects, Old and New

(Project leaders' affiliations and addresses are given in membership list at end of these Proceedings)

A. Forest Disease Surveys - General

- 53-A-1. Forest disease surveys in Alberta, the Rocky Mountain National Parks, and Northwest Territories (R. J. Bouchier).
- 53-A-3. Disease survey in British Columbia (A. C. Molnar and W. G. Ziller).
- 56-A-1. Forest disease conditions in California (D. R. Miller).
- 57-A-1. Forest disease sampling studies (R. E. Foster).
Objective: To appraise the relative precision and efficiency in estimating forest disease through application of different sampling systems to Douglas-fir plantations.
- 57-A-2. Field key of forest diseases in California (H. H. Bynum).
Objective: To provide cooperators and seasonal workers in the Forest Disease Survey program with an easy-to-carry, easy-to-use key of the commonly encountered diseases of conifers in California.
- 57-A-3. Exotic plantation studies (A. C. Molnar).
Objective: To catalog the plantations of nonindigenous tree species in British Columbia and carry out periodic examinations to evaluate pathological disturbance (previously listed as 56-K-1).

B. Noninfectious Diseases

None.

C. Cone, Seed, and Seedling Diseases

- 53-C-2. Control of diseases of seeds and seedlings of forest trees in California (R. V. Bega).
- 53-C-4. Nursery and plantation diseases (G. M. Harvey).
- 53-C-5. Damping-off and other diseases in forest nurseries (P. J. Salisbury).
- 57-C-1. Molds of forest tree seed (K. R. Shea).
Objective: To investigate the molds commonly found on cones and seeds of western forest trees. Items under study include the incidence and kinds of molds and factors concerning epidemiology, damage, and control.

D. Root and Soil Diseases or Relationships

- 53-D-2. Poria weirii root rot of Douglas-fir (T. W. Childs).
- 53-D-3. Poria weirii root rot of Douglas-fir (G. W. Wallis)
- 53-D-4. Characteristics and ecology of the root system of western white pine (R. G. McMinn).
- 53-D-5. Characteristics and ecology of the root system of Douglas-fir (R. G. McMinn).
- 53-D-6. Phytophthora root rots of Port-Orford-cedar and Douglas-fir (L. F. Roth).
- 53-D-7. Phytophthora root rot of coniferous trees in British Columbia (P. J. Salisbury).
- 53-D-8. Root diseases of forest conifers (W. W. Wagener).
- 54-D-1. Survey of Phytophthora lateralis root rot within the native range of Port-Orford-cedar (J. Hunt).
- 55-D-1. Root stain disease of eastern white pine (C. D. Leaphart).
- 55-D-2. Soil moisture in relation to the pole blight disease (C. D. Leaphart).
- 55-D-3. Mycorrhizal relationships of healthy and pole-blighted western white pine (R. L. Gilbertson).
- 56-D-1. Influence of mycorrhizae on survival and development of Douglas-fir seedlings (J. E. Bier).
- 56-D-2. Effect of artificially imposed moisture stress on rootlet mortality of western white pine and associate tree species (C. D. Leaphart).
- 57-D-1. Armillaria mellea on ponderosa pine (J. Hunt).
Objective: To determine rate and extent of damage, and factors associated with the buildup and spread of the disease.
- 57-D-2. Trend of Armillaria mellea infection in mature stands of Pacific silver fir (G. M. Harvey).
Objective: To investigate possible relationships between Armillaria infection and attack by engraver beetles.
- 57-D-3. Poria weirii root rot of Douglas-fir (A. K. Parker).
Objective: To study the biology and host-parasite relationships of Poria weirii.

E. Foliage Diseases

- 53-E-1. Elytroderma needle cast of ponderosa pine (T. W. Childs and John Hunt).
- 53-E-2. Rhabdocline and Rhabdogloeum needle casts of Douglas-fir (A. K. Parker).
- 53-E-4. Needle diseases of western pines (W. W. Wagener).
- 53-E-5. The Hypodermataceae of conifers in British Columbia (W. G. Ziller)
- 54-E-1. Rhabdocline on Douglas-fir (C. W. Waters).
- 57-E-1. Elytroderma deformans (C. W. Waters).
Objective: To study the life history of the pathogene.
- 57-E-2. Needle cast of ponderosa pine in Arizona and New Mexico (S. R. Andrews).
Objective: To determine the cause or causes and pathological importance of this needle cast.
- 57-E-3. Taxonomic studies of principal fungi associated with ponderosa pine needle cast in Arizona (P. D. Keener).
Objective: To determine the taxonomic position of the principal fungi associated with needle cast of ponderosa pine on the Prescott and Coconino National Forests.
- 57-E-4. Life history studies of Elytroderma deformans (L. F. Roth).
Objective: To work out the life history of the fungus and to determine the critical range of environmental factors that govern infection.

F. Stem Diseases - Malformations, witches' brooms, dwarfmistletoes, etc.

- 53-F-1. Biological and chemical control of dwarfmistletoe (R. J. Bouchier).
- 53-F-2. Dwarfmistletoes of the Rocky Mountain Region (L. S. Gill).
- 53-F-3. Biological studies of dwarfmistletoes in Alberta
- 53-F-4. Dwarfmistletoe of ponderosa pine (L. F. Roth).
- 54-F-2. Spray control of lodgepole pine mistletoe (J. L. Mielke).
- 54-F-3. Dwarfmistletoe survey in Arizona and New Mexico (S. R. Andrews and F. G. Hawksworth).
- 55-F-2. Chemical control of dwarfmistletoes of conifers in California (R. V. Bega).
- 55-F-3. Dwarfmistletoe of western larch and lodgepole pine (C. W. Waters).

- 56-F-1. Dwarfmistletoe of ponderosa pine (K. R. Shea).
- 56-F-2. Distribution and damage surveys of the dwarfmistletoes (D. P. Graham).
- 57-F-1. Dwarfmistletoes of western larch, lodgepole pine, and Douglas-fir (C. W. Waters).
Objective: To obtain additional basic information concerning the mistletoe parasite and its relation to the host.
- 57-F-2. Some studies of Douglas-fir mistletoe and tissue culture of the host (L. Blakely & C. W. Waters).
Objective: To study the physiological relations existing between host and parasite; germination of seeds and explore the possibility of growing the pathogene in tissue cultures.
- 57-F-3. Distribution and damage surveys of the dwarfmistletoes (D. P. Graham).
Objective: To determine the abundance and intensity of dwarfmistletoe and the amount and rate of damage.
- 57-F-4. Dwarfmistletoes on ponderosa pine and Douglas-fir (J. Hunt).
Objective: To appraise damage and devise control methods. (This project includes 54-F-1 and 55-F-1).
- 57-F-5. Environmental and host-parasite relationships of dwarfmistletoes (J. R. Parmeter, Jr., and R. F. Scharpf).
Objective: To determine quantitatively the influence of light, temperature, moisture, and aging on germination of an infection by dwarfmistletoe seeds; and to determine host responses associated with the failure of dwarfmistletoes to infect unsuitable hosts.
- 57-F-6. Fungus diseases of dwarfmistletoes (J. R. Parmeter, Jr., and R. V. Bega).
Objective: To determine the impact of mistletoe diseases on mistletoe seed production and intensity of damage in areas where such diseases are prevalent; to determine the disease cycles and the environmental conditions necessary for maximum disease intensity; and to evaluate the possibilities of inducing mistletoe-disease epidemics in infested stands.
- 57-F-7. Fungi associated with branch dieback in mistletoe-infected conifers (J. R. Parmeter, Jr.).
Objective: To determine the role of fungi in branch dieback of mistletoe-infected conifers and to identify the fungi involved; to determine the disease cycles of the more important fungi involved; and to determine the effect of branch dieback on growth and vigor of the host, mistletoe seed production, and the over-all effect on the spread and development of mistletoe in forest stands.
- 57-F-8. Survey of dwarfmistletoe on commercial conifers in Arizona and New Mexico (F. G. Hawksworth).

Objective: To determine the extent of and damage caused by dwarfmistletoe in Arizona and New Mexico.

- 57-F-9. Comparative anatomical study of conducting tissue of Arceuthobium-infected and noninfected conifers (Calif. For. Expt. Sta. contract research with Univ. of Calif. at Davis--L. Srivastava and Dr. Katherine Esau).

G. Stem Diseases - Stains and decays

- 53-G-1. Red rot (Polyporus anceps) in ponderosa pine (S. R. Andrews).
- 53-G-3. Decay in high-elevation tree species of the central Rockies (F. G. Hawksworth).
- 53-G-4. Decay of subalpine spruce on the Rocky Mountain Forest Reserve in Alberta (D. E. Etheridge).
- 53-G-5. Root and butt rot of subalpine spruce on the Rocky Mountain Forest Reserve in Alberta (D. E. Etheridge).
- 53-G-7. Cull and breakage factors for California (H. H. Bynum).
- 53-G-10. Some aspects of the ecology of the Indian paint fungus in British Columbia (G. P. Thomas).
- 53-G-13. "Red stain" and decay of lodgepole pine injured by fire in Alberta
- 54-G-2. Decay of alpine fir in the Prince George Forest District (N. T. Engelhardt).
- 54-G-4. The influence of moisture and other factors on the activity of heartwood fungi in subalpine spruce (D. E. Etheridge).
- 55-G-1. Correlation of the rate of extension of heart rots in living California trees with air temperature (L. A. Paine).
- 55-G-2. Cull indicator factors for red fir in the Sierra subregions (H. H. Bynum).
- 55-G-4. Hyphal fusions and their value in identifying various species of Thelephoraceae (R. J. Bouchier).
- 56-G-1. Heart rots of young-growth Douglas-fir (G. M. Harvey).
- 56-G-2. Decay of lodgepole pine (J. Hunt).
- 56-G-3. Decay of Pacific Coast alder (G. M. Harvey).

- 57-G-1. Loss factors for a continuous forest inventory in British Columbia (J. E. Browne).
Objective: To provide decay, waste, and breakage factors suitable for local application in a continuous forest inventory.
- 57-G-2. Significance of the heartwood stains of lodgepole pine (H. W. Eades & J. W. Roff).
Objective: To study the red heartwood colorations of lodgepole pine and identify the causal organisms; also to determine the strength properties and durability of stained wood.
- 57-G-3. Significance of the black heartwood stains of yellow cedar (H. W. Eades & J. W. Roff).
Objective: To identify the organisms associated with black stain in yellow cedar, to study their role in the decay of this species and to determine the effect of this coloration upon strength and durability of the wood.
- 57-G-4. Studies on Idaho wood-rotting fungi (R. L. Gilbertson).
Objective: To obtain basic information on the identity, host range, type of rot, cultural characteristics, and distribution of the fungi responsible for decay of living and dead timber in Idaho forests.
- 57-G-5. Temperature-growth rates of Echinodontium tinctorium in vitro (L. A. Paine).
Objective: To obtain reliable data on temperature-growth rates for individual strains and on range of strain variation with respect to growth rates and optimum temperatures; to investigate the reliability of common plate culture growth measurement techniques; and, in conjunction with another study on tree temperatures, to expose any correlations between fungus growth rates and local climate.
- 57-G-6. Cull indicators in Engelmann spruce (F. G. Hawksworth).
Objective: To correlate external characters of trees and stands with cull in Engelmann spruce in Colorado.
- 57-G-7. Navajo defect study (S. R. Andrews).
Objective: To determine the importance of red rot cull in ponderosa pine reserved for second and subsequent cuts on the Defiance Plateau of the Navajo Indian Reservation.
- 57-G-8. Scar-damaged spruce-balsam forests (A. K. Parker)
Objective: To determine the susceptibility of scars to fungus infections; to determine the volumetric decay losses associated with scars; to appraise the influence of scar size and position, tree size, tree species, and forest site.

- 57-G-9. The fungus flora of living lodgepole pine and its possible role in decay development (R. J. Bouchier).
Objective: To determine the fungus flora of lodgepole pine stems that do not show any evidence of decay; to determine host-fungus relationships, the portion of the wood inhabited, the possible points of entry of the fungi, and their ability to cause decay as measured by loss in weight of the wood; to determine whether wood that has been attacked by these fungi imperfecti is more susceptible or resistant to attack by the principal wood-rot fungi; to determine whether any of these fungi show antagonism to the principal wood-rot fungi.
- 57-G-10. Ecology of branch stub infection in aspen (D. E. Etheridge).
Objective: To study the factors associated with the deterioration of dead branches; to determine the seasonal changes in moisture content and the fungal flora present in dead branches of increasing age, and to examine the relative humidity of the surrounding air, the age at which branches are normally shed, and the length of time required for trees to cover exposed branch stubs; to determine how site and tree vigor may influence the course of infection; to determine at what age and under what conditions wood-destroying fungi, particularly Fomes igniarius, may enter the succession and attack the heartwood.

H. Stem Diseases - Rusts and Cankers.

- 53-H-2. Testing progeny of resistant pines for susceptibility to white pine blister rust in the Inland Empire (R. T. Bingham).
- 53-H-3. White pine blister rust (W. A. Porter).
- 53-H-4. Blister rust canker development following artificial and natural inoculation (A. W. Slipp).
- 53-H-5. Native rusts of western pines (J. L. Mielke).
- 53-H-6. Forest tree rusts of British Columbia (W. G. Ziller).
- 54-H-2. Rate of growth of white pine blister rust cankers on sugar pine in California (D. R. Miller).
- 54-H-3. White pine blister rust (G. M. Harvey).
- 54-H-4. Status-of-control plots (D. R. Miller).
- 54-H-5. Summary of disease survey and scouting data (D. R. Miller).
- 54-H-7. Test fungicides for protection of white pines (C. R. Quick).
- 54-H-8. Search for blister-rust-resistant white pines (C. R. Quick).
- 54-H-9. Appraisal and prediction of timber losses caused by blister rust (D. R. Miller).

- 54-H-10. Analysis of physical and ecological site factors contributing to high rust hazard (C. R. Quick).
- 54-H-11. Epidemiology of blister rust (R. V. Bega).
- 55-H-2. Tests of fungicides to inhibit blister rust development on the leaves of ribes bushes (C. R. Quick).
- 55-H-4. Effect of microclimatic conditions on the distribution and spread of white pine blister rust in California. (R. V. Bega).
- 56-H-1. Testing sequential sampling techniques for surveys of ribes populations and rust damage (H. R. Offord).
- 56-H-2. Ribes ecology in relation to blister rust control and white pine management (C. R. Quick & V. D. Moss).
- 56-H-3. Development and improvement of chemical methods for the eradication of ribes (C. R. Quick & V. D. Moss).
- 56-H-4. Distance of spread and rust losses to sugar pine associated with prescribed control standards (D. R. Miller).
- 56-H-5. Relationship of the spread and intensification of blister rust in the Inland Empire area to the microclimate (M. G. Lloyd).
- 56-H-6. Etiological, host-parasite, and ecological investigations of the Atropellis disease of lodgepole pine in Alberta (J. C. Hopkins).
- 57-H-1. Canker and dieback fungi on Sequoia, Libocedrus, Ericaceous species, and other California tree species (J. R. Parmeter, Jr., & R. V. Bega).
Objective: To determine the relationships of Botryosphaeria and associated pycnidial genera to cankers and dieback of California tree species, particularly bigtree, incense-cedar, madrone, and California laurel.
- 57-H-2. Vegetative propagation of sugar pine for disease resistance tests (C. R. Quick).
Objective: To explore methods for vegetative propagation of sugar pine, and to propagate clones for disease resistance tests and for subsequent seed orchard establishment.
- 57-H-3. Factors associated with juniper mortality in Arizona and New Mexico (W. E. Eslyn).
Objective: To determine the cause or causes of widespread juniper mortality in Arizona and New Mexico.
- 57-H-4. The relation of bark moisture to the development of Cryptodiaporthe canker on willow (J. E. Bier).

I. Wilt and Blight Diseases

- 53-I-1. Pole blight of western white pine (C. D. Leaphart).
- 53-I-3. Pole blight of western white pine (R. G. McMinn, A. K. Parker & A. C. Molnar).
- 53-I-5. Survey of western white pine pole blight (D. P. Graham).
- 55-I-2. Effect of silvicultural measures on the white pine pole blight disease (D. P. Graham).
- 56-I-1. Dieback of sapling Douglas-fir in coastal British Columbia (W. A. Porter).
- 57-I-1. Rate of progress of pole blight (D. P. Graham).
Objective: To determine the present trend of pole blight as related to its progress in the past.

J. Defects and Decays of Forest Products - Dead timber, slash, etc.

- 53-J-1 Deterioration of slash of lodgepole pine in Alberta
- 53-J-2 Deterioration of wind-damaged spruce and balsam forests (N. T. Englehardt).
- 56-J-1. Decay of killed Douglas-fir in interior British Columbia (G. P. Thomas).
- 56-J-3. Deterioration of beetle-killed and windthrown Douglas-fir (G. M. Harvey).
- 57-J-1. Relative durability of western redcedar heartwood under accelerated laboratory test conditions (H. W. Eades and J. W. Roff).
- 57-J-2. Deterioration of logging residues (H. W. Eades & J. W. Roff).
- 57-J-3. Relative decay resistance of western hemlock, Sitka spruce, and Douglas-fir plywood (H. W. Eades & J. W. Roff).
- 57-J-4. Deterioration of Chermes-killed Pacific silver fir (K. R. Shea).
Objective: To find external indicators of the time the trees have been dead and the extent of deterioration so as to develop guides for salvage and management; to identify insects and fungi associated with dead and deteriorating trees; and to determine the pulping characteristics of Chermes-killed trees dead for varying periods.

- 57-J-5. Post-logging decay in western hemlock and Sitka spruce (K. R. Shea).
Objective: To determine amount of decay associated with logging scars of various sizes by tree species, types of decay associated with injuries and their relative importance, and applicability of table designed by Wright and Isaac for determining decay loss for scars of known age and area.

K. Miscellaneous Studies

- 53-K-1. Survival of fire-damaged trees (W. W. Wagener).
- 54-K-1. An undescribed disease on Rocky Mountain juniper (C. W. Waters).
- 54-K-2. Vegetative propagation of disease-resistant western white pine (C. W. Waters).
- 56-K-2. Disease surveys and pathogenicity tests on selected clones of poplar, including introduced varieties (J. E. Bier).
- 57-K-1. Fungicidal properties of western redcedar extractives (J. W. Roff).
Objective: To make toximetric studies of substances isolated from western redcedar heartwood.
- 57-K-2. Bio-assay of "Agri-mycin-100"-treated Pacific silver and noble firs (K. R. Shea).
Objective: To determine the prevalence and relative amounts of Agri-mycin-100 in sprayed seedlings of Pacific silver and noble firs by bio-assay techniques.

APPENDIX II

Terminated Projects

(Project leaders' affiliations and addresses are given in membership list at end of these Proceedings. For publications see Appendix IV)

- 53-C-3. Microflora of conifer seed (P. J. Salisbury)
- 54-D-6. Physical soil factors associated with pole blight of western white pine (O. L. Copeland, Jr.)
- 54-D-7. Rootlet mortality studies of western white pine (C. D. Leaphart)
- 56-D-3. Distribution and condition of the root systems of tree species in western white pine stands (C. D. Leaphart)

In pole-blighted stands, ratio of rootlet length to length of parent lateral roots (less than 10 mm. diameter) was less in white pine than in its sub-climax competitors, and much less than in its climax competitors.

- 53-E-3. Keithia blight of cedar (W. A. Porter)
- 53-G-2. Decay analyses of commercial tree species in British Columbia (J. E. Browne).
- 54-G-1. Decay in relation to priority of cutting (W. A. Porter).
- 54-G-3. Decay of western hemlock and amabilis fir in the upper Kitimat region, B. C. (R. E. Foster)
- 56-G-5. Fungi associated with decay of Douglas-fir and western yellow pine in the interior region of British Columbia (A. C. Molnar).
- 54-I-1. Damage surveys of pole blight (D. P. Graham)
- The annual mortality and growth loss was estimated to be 174 cu. ft. per acre over the 102,000 acres now affected.
- 55-I-1. Effect of pole blight on growth and mortality in white pine thinning plots (D. P. Graham).
- Damage, in terms of basal area, was 2.6 times as great on thinned plots as on unthinned plots.
- 53-J-3. Deterioration of looper-defoliated western hemlock on lower Vancouver Island (N. T. Engelhardt).

APPENDIX III

New and Modified Techniques

(Authors' affiliations and addresses are given in membership list at end of these Proceedings)

1. Silver iodide generator method of studying spore dispersion
(M. G. Lloyd).

Silver iodide can be used to simulate spore distribution patterns from a known source or sources when the actual spores are difficult to trap or identify, or are released in nature from so many other sources that the origin of those trapped would be doubtful.

First, silver iodide particles are dispersed into the atmosphere by means of silver iodide "smoke" generators at a given point under controlled conditions during periods when meteorological conditions would favor spore release.

Air samples are then taken at any number of localities in the area and introduced into a cold chamber (-20° C.) containing a supercooled moisture cloud. Any silver iodide particles present in the introduced air sample will act as "sublimation nuclei" around which the supercooled water freezes and grows into a tiny snowflake whose coruscations can be seen when a strong light is thrown at an angle into the box.

If a numerical measure of distribution is needed, particles per liter of air sampled can be determined and compared with the number of particles released by the generator or the number of particles obtained in samples at other localities.

2. Rapid recording of plate culture growth measurements (Lee A. Paine).

A portable tape recorder with microphone and foot control was adapted for recording fungus culture growth data. In large runs, the time required for measurement and recording growth data by one person is often a disturbing factor. The length of time during which a plate remains out of the temperature chamber and the span of hours over which a series of plates are handled during a day may be reduced by more than 50 percent with the tape recorder and subsequent transcription of the data. Use of the foot control during recording permits playback of a continuous series of readings and an appreciable decrease in total data handling time. The small Wollensak recorder with foot control accessory was found to be excellent for this purpose. Operating costs are minimal since a single tape may be re-used indefinitely. Data may also be stored for subsequent transcription by clerical personnel directly on to IBM cards at an initial tape cost of \$1.27 per hour at 3.75 i.p.s.

3. A modified technique for use in measuring the extent of sapwood decay in logs (J. W. Roff)

In a study of the deterioration of logging residue, the irregularity in form and occurrence which characterizes the decay of sapwood made it essential to devise a more precise method to record and measure its extent in logs than that commonly used.

Sap rots differ largely from heart rots in that the latter advance within the tree and their development is affected to a great extent by the growth processes of the tree species concerned. Sap rots, on the other hand, occur on the periphery and they are also affected by the ambient, particularly as regards to the presence of moisture. Rot in the heartwood is somewhat regular in outline, its columnar form approximates that of the log itself so that in log scaling, the volume of rot is closely related to the cross-section areas exhibited upon the ends and may be expressed by mathematical formula. Sap rots, however, are often discontinuous along one side or in one portion of the periphery, their distribution and development being largely related to the occurrence of a favorable microclimate at that position. In this case, the use of a graphic method for measuring their volumes appears advantageous.

In research studies, the method commonly used consists of cross-section paper where the scale of areas is graduated in terms of the diameter so that the form of the tree or of the rot portion concerned is represented by a series of points marked at appropriate distances from an origin. While this method is simple to apply when dealing with regular shapes, a considerable degree of estimation is required to determine an average diameter for eccentric bodies such as the butt ends of certain basal logs or to express an average depth in the case of an irregular, crescent-shaped rot pocket at the periphery.

On account of these and other eccentricities which prevailed and in order to reduce the amount of estimation required in the field, the following procedure was developed:

Starting at the butt, each piece was bucked into short sections until the minimum top diameter was reached, then by examination of the several section faces, the condition of the entire piece was determined. Inspection began at the butt end of section one and when the decay was exposed, the position and outlines of the rotted portion were reproduced by measuring at several points about the circumference and by plotting these dimensions to scale upon field sheets printed with a series of concentric circles representing the ends of sections. When these several points were joined the resulting diagram showed the relative position and area of the visible rot contained at the base of section one.

Proceeding to section two, a similar procedure was followed and as the measurements were again taken at the lower end, the diagram at once depicted the rot condition at the butt of section two as well as that depicted at the top of section one. These two diagrams were afterwards planimetered and their areas averaged.

The resulting figure multiplied by the length of the section gave the volume contained in that section.

The procedure was repeated for each succeeding section in the piece, a separate diagram being prepared in each case and their several volumes being afterwards totalled.

The technique was also used to represent areas of eccentric log ends where an average diameter was not sufficiently accurate. In such cases an arbitrary log center was established and measurements taken from this center to various points about the circumference, were plotted upon the sheet. The outline of the rotted portion was then measured in a similar way and its boundaries depicted as before.

APPENDIX IV

Publications

1. Bega, Robert V. The use of detached ribes and pine leaves in studies with Cronartium ribicola. *Phytopathology* 47:9. 1957.
2. Bouchier, R. J. Variation in cultural conditions and its effect on hyphal fusion in Corticium vellereum. *Mycologia* 49: 20-28. 1957.
3. Buckland, D. C., and G. W. Wallis. The control of yellow laminated root rot of Douglas-fir. *For. Chron.* 32:14-16. 1956.
4. Copeland, Otis L., Jr. Preliminary soil-site studies in the western white pine type. *Intermountain For. & Range Expt. Sta. Res. Note* 33. 4 pp. 1956.
5. Engelhardt, N. T. Pathological deterioration of looper-killed western hemlock on Southern Vancouver Island. *For. Sci.* 3(2): 125-136. 1957.
6. Etheridge, D. E. Comparative studies of Coryne sarcoides (Jacq.) Tul. and two species of wood-destroying fungi. *Can. Jour. Bot.* 35 595-603. 1957.
7. _____ . A method for the study of decay resistance in wood under controlled moisture conditions. *Can. Jour. Bot.* 35:935-944. 1957.
8. _____ . Relationships between site and decay in subalpine spruce in Alberta. *Can. Dept. Agr. For. Biol. Div., Bi-monthly Prog. Rept.* 13(5): 1-2. 1957.
9. Foster, R. E. Forest disease investigations. Ann. report of the For. Serv., Prov. of Brit. Col., Victoria. 1957.
10. _____ . Pole blight of western white pine. *Timber of Canada.* 18(9): 60, 62, 63, 65, 66, 100. 1957.
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12. Kimmey, J. W. Dwarfmistletoes of California and their control. *Calif. For. & Range Expt. Sta. Tech. Paper* 19. 12 pp. 1957.
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16. _____, Otis L. Copeland, Jr. Root and soil relationships associated with the pole blight disease of western white pine. Soil Science Soc. of America Proc. 21:551-554. 1957.
17. McMinn, R. G. Studies on the root ecology of healthy and pole blight affected white pine. Can. Dept. Agric. For. Biol. Div., Bi-monthly Prog. Rept. 12(6):3. 1956.
18. Mielke, J. L. Aspen leaf blight in the Intermountain Region. Intermountain For. & Range Expt. Sta. Res. Note 42. 5 pp. 1957.
19. _____. The Comandra blister rust in lodgepole pine. Intermountain For. & Range Expt. Sta. Res. Note 46. 8 pp. 1957.
20. _____. The yellow witches' broom of subalpine fir in the Intermountain Region. Intermountain For. & Range Expt. Sta. Res. Note 47. 5 pp. 1957.
21. Molnar, A. C. Province of British Columbia Forest Disease Survey. Ann. Rept. of the For. Insect and Disease Surv. Can. Dept. Agric. For. Biol. Div., Ottawa. 1957.
22. _____ and E. H. Garman. Introduction of exotic trees to British Columbia. B. C. Lumberman 42 (3): 36-37. 1958.
23. Nordin, V. J. Diseases of lodgepole pine in Alberta. Can. Dept. Agric., Forest Biol. Div. (mimeographed) 28 pp. 1957.
24. _____. Insects associated with fire-scarred lodgepole pine in Alberta. Can. Dept. Agr., Forest Biol. Div., Bi-monthly Prog. Rept. 12(6):3. 1956.
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30. Salisbury, P. J. Heavy damage to Chinese junipers, Juniperus chinensis L., associated with Pestalotia funerea Desm. Can. Dept. Agric. For. Biol. Div., Bi-monthly Prog. Rept. 13(6):4. 1957.
31. _____ . A test of three disinfectants in nursery soil. Can. Dept. Agric. For. Biol. Div., Bi-monthly Prog. Rept. 13(3):3-4. 1957.
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33. Wagener, Willis W. The limitation of two leafy mistletoes of the genus Phoradendron by low temperatures. Ecology 38:142-145. 1957.
34. Wallis, G. W. and S. A. Wilde. Rapid method for the determination of carbon dioxide evolved from forest soils. Ecology 38(2): 359-361. 1957.
35. Ziller, W. G. Studies of western tree rusts. III. Milesia laeviuscula, a needle rust of grand fir. Can. J. Bot., 35(6): 885-894. 1957.

APPENDIX V

Minutes of the Business Meeting

Friday, December 6, 1957

Chairman Thomas called the meeting to order at 1:30 p.m. It was moved and seconded that the reading of last year's minutes be dispensed with. Motion carried. The Treasurer submitted the following report:

	<u>Expenditures</u>	<u>Receipts</u>
40 registrations at \$2.50		\$ 100.00
40 banquet tickets at \$2.50		100.00
Coffee and cups (Corvallis field trip)	\$ 1.00	
Receipt book for registrations	.25	
41 dinners (banquet)	102.50	
Social hour costs	43.95	
Tip	12.00	
	<u>\$ 159.70</u>	<u>\$ 200.00</u>
Balance on hand		<u>-159.70</u> 40.30

It was moved and seconded that this report be accepted. Motion carried.

D. C. Buckland Memorial Committee. J. E. Bier reported that action by the committee had been postponed until a complete set of the late Dr. D. C. Buckland's publications can be collected and bound.

Decay Standards Committee. R. E. Foster reported that the proposed standards, as developed by this committee, would soon be multilithed by the Victoria Laboratory in a form to permit citation, and would be distributed to the membership in time to permit action by the Sixth Conference.

Plot Standardization Committee. A. C. Molnar reported that this subject had been found not readily amenable to treatment by committee. It was suggested that cooperative arrangements, either local or regional, would be more effective, and that success along these lines should be reported to future Conferences. Dissolution of the committee was requested. So moved and seconded. Motion carried.

Committee on Status of Dwarfmistletoe Research reported as follows:

1. Surveys and demonstration or pilot tests of control by currently approved practices. Ecology of dwarfmistletoe in stand development and forest succession.

- a. Evaluation of significance in timber management: (1) amount and location, (2) correlation with soil-vegetation classes, (3) sizes of infected trees and volumes involved, (4) association with tree risk classification. Klamath Falls, Oregon, Antelope Unit. Weyerhaeuser Timber Company (Keith Shea).
- b. Silvicultural control, three replicated blocks and four treatment studies in heavily infected ponderosa pine stand. Klamath Falls, Oregon. Weyerhaeuser Timber Company (Keith Shea).

Five-year examination of Fort Valley control plots. Rocky Mountain Station (Gill, Andrews, Hawksworth).

At California and Pacific Northwest Stations there are in progress and scheduled several small-scale tests of control by silvicultural means. Dwarfmistletoe to be included as one of the variables in the spacing-increment studies proposed for 1957 by Deschutes Research Center.

- c. Appraisal and post-control surveys in Rocky Mountain region. Lodgepole pine appraisal survey completed, report being prepared.

Arizona-New Mexico regional survey to be completed in 1957. Grand Canyon-Grandview extension. Post-control surveys involving use of temporary 1/10-acre plots on Mescalero Indian Reservation and on Grand Canyon National Park use of four observation plots and about 5 percent of trees treated on three of these plots. Additional survey for National Park Service planned for Saguaro National Monument on ponderosa pine.

At Pacific Northwest Station small-scale surveys of dwarfmistletoe in ponderosa pine were not entirely satisfactory and some attention will be given to test use of sequential sampling of understory infection intensities. William Pierce, graduate student, University of Washington, has studies in progress on damage appraisal in Douglas-fir.

At California Station dwarfmistletoe infection is recorded on series of permanent mortality and disease plots. Three sale areas, one in Jeffrey pine, one in ponderosa pine, and one in red fir, are being marked for dwarfmistletoe control, all in respect to unit area control. No systematic survey for dwarfmistletoe on region-wide basis.

The spread and intensification of dwarfmistletoe in ponderosa pine to determine the pattern of infection in regeneration as related to infectious overstory. Weyerhaeuser Timber Company (Keith Shea).

- d. Effects of dwarfmistletoe on growth of host trees reported by Rocky Mountain Station from increment core measurements. Uninfected dominants grew about twice as fast in a 5-year period as did dominants with heavy dwarfmistletoe in crown. Marked growth reduction does not take place until crown is quite generally infected.
 - e. Spread and intensification studies of Rocky Mountain Station showed spread of 0.9 foot per year from infected overstory in Douglas-fir and from 1.3 to 5.6 feet per year in ponderosa pine stands, rate of spread being largely dependent on density of the understory.
2. Taxonomic and anatomic studies of the genus Arceuthobium and their hosts. Specificity of hosts to various forms of dwarfmistletoe and cross-over phenomena.
- a. Anatomical and functional aspects of conducting tissues of Arceuthobium and coniferous hosts. L. Srivastava, graduate student at University of California at Davis.
 - b. Taxonomic and anatomical aspects of Arceuthobium spp. including germination and extension of attached seed into host tissue and development of the endophytic system. Job Kuijt at University of California, Botany Department, Berkeley.
- Rocky Mountain Station on rate of haustoria advance in ponderosa pine tissue.
- c. Extension of endophytic system in relation to external evidence and development and placement of the sinkers within host tissue. (Master's thesis, University of California, by Robert F. Scharpf, now graduate student in Plant Pathology with Dr. Parmeter.) Also Abstr. same subject by Keith Shea, *Phytopath.* 47: 534.
 - d. An investigation of the endophytic system of Arceuthobium douglasii, a master's thesis by Robert V. Parke, University of Washington, 1951.
 - e. Degree of specificity in various forms of A. campylopodium to host species and cross-over infections from different host species growing in close association. J. R. Parmeter at University of California.
3. Physiological studies of host-parasite, germination, establishment, growth, and reproduction of dwarfmistletoe. Effects of dwarfmistletoe on host.
- a. Movement of materials between ponderosa pine and dwarfmistletoe. Study of inorganic translocation--foliar and nutrient (soil) absorption using radioactive P^{32} . Organic translocation--tagged C^{14} used in controlled synthesis studies.

Dye and Iodine ¹³¹ tracer to be used to check xylem and phloem translocation on small infected P. ponderosa (about 4-foot test trees). Weyerhaeuser Timber Company (John Rediske and Keith Shea).

Tree injection studies, probably of western hemlock, using radioactive tracers or stains to provide information on the volume, distribution, and uptake of water and nutrients in different parts of diseased and healthy trees. Correlation of mistletoe injection with the moisture content of the host tissue. (Suggested for study at University of British Columbia (Jack Bier)).

- b. Minor element nutrition of ponderosa pine and dwarfmistletoe. Compare tolerance normal and infected seedlings to low concentration of Cu, Zn, Mn, B, etc. Weyerhaeuser Timber Company (John Rediske and Keith Shea).

A closely related study is that proposed by C. W. Waters in which potted and infected small larch will be grown under various conditions of nutrient, light, temperature, and moisture. Attempts will also be made on tissue culture of dwarfmistletoe by Waters and in similar studies by Parmeter at California.

- c. Artificial infection of ponderosa pine by seed placement and by bark grafts transferring infected tissue. Field tests. Weyerhaeuser Timber Company (Keith Shea).

Additional studies in this field scheduled by J. R. Parmeter and Robert F. Scharpf, University of California, Berkeley.

C. W. Waters at Montana State University has planned studies of the flowering, seed production, and viability of seed from dwarfmistletoe on western larch, lodgepole pine, and Douglas-fir. These studies will include natural and artificial infections.

Progress reported by Rocky Mountain Station on observations of naturally planted seeds (1,000) in 1950 on sex ratio and percent of seeds that later developed shoots and seeds in a 6-year period.

4. Chemical and biological control.

Since Lake Gill's excellent report to the Conference in 1955 on progress of chemical tests for dwarfmistletoe control, further field trials of likely toxicants have been made at Inter-mountain and California Stations and further observations on effects of earlier tests have been made at Pacific Northwest and Rocky Mountain Stations. At Montana State University, C. W. Waters plans to test chemicals on potted and infected

trees to facilitate an understanding of the translocation mechanism. Anatomical research on conducting tissue in host and parasite now in progress at the University of California at Davis is aimed at an explanation of the movement of water and carbohydrate in conducting tissues of host and parasite.

No toxicant has yet been found that is selectively lethal to dwarfmistletoe and harmless to the host tree.

No planned research has been reported on biological control. Several parasitic insects and fungi have been reported.

/s/ J. E. Bier
K. R. Shea
H. R. Offord (Chairman)

Chairman Thomas presented the following report of a committee of members to evaluate the objectives, organization, and activities of the Western International Forest Disease Work Conference:

Objectives.

Recommendation: Through discussion at a professional level to provide a continuing opportunity for forest pathologists in western North America to exchange views on problems of mutual interest and concern to their field as regards survey, research, control, and extension activities.

Comment: The Committee visualizes the Conference as the only medium available to pathologists to discuss pathology at an appropriate level and on an informal basis. Meetings of scientific societies and the journals they publish are considered inadequate for this purpose. The committee stresses the continuing need for a work conference to assure the exchange of ideas that is necessary to avoid professional isolation.

Organization. I. Membership

Recommendation: Membership in the Conference to accrue to persons actively engaged in tree disease research, forest products pathology research, administration of either type of research, and university teaching of forest pathology principles. Participation in Conference activities by workers in fields related to forest pathology is recommended on a discontinuous basis.

Comment: The committee agreed that the Conference should neither become an instrument for making public the results of research nor should it aspire to the proportions of a

scientific society. Consequently, its activities would be of interest to only those persons as recommended for membership. It was considered that increased membership, beyond that which is recommended, could lower the level of discussion and weaken the framework for cooperative action on problems of mutual concern.

Organization. II. Officers.

- Recommendation 1: That a chairman and a secretary be elected by the attending members at the termination of each meeting and that the chairman-elect be given the authority to appoint persons within the membership to assist him and the secretary to carry out Conference activities.
- Recommendation 2: That a chairman and a secretary be elected by the attending members at the termination of every other meeting, i.e., to serve in office until the termination of two successive meetings, and that the chairman-elect be given the same authorities as in Recommendation 1.
- Recommendation 3: That a chairman be elected by the attending members at the termination of each meeting and that he be given the same authorities as in Recommendation 1.
- Recommendation 4: That a chairman be elected by the attending members at the termination of every other meeting, i.e., to serve in office until the termination of two successive meetings, and that he be given the same authorities as in Recommendation 1.

Comment: The committee agreed that the number of elected officers be kept low in keeping with the idea of the Conference avoiding any semblance with a scientific society. Inasmuch as the chairman would be vested with the authority to solicit assistance from the membership, it would be possible for the Conference to function with only one elected officer. On the other hand, if meetings are scheduled for intervals of greater than one year, it might develop that the demands upon the time of the chairman are out of keeping with his obligations to his employer.

Organization. III. Affiliation with other groups

- Recommendation: That the Conference should not affiliate with any other group but should encourage concurrent meetings and, occasionally, joint sessions with them whenever such associations can be shown to be beneficial to the Conference.

Comment: The committee was agreed that the Conference should preserve its identity and not subscribe regularly to the objectives and activities of other groups. It recognized, however, that meeting concurrently with other groups could be turned to the advantage of the Conference. Similarly, the committee recognized that joint sessions with other groups could at times be beneficial. It was agreed, however, that neither concurrent meetings nor joint sessions should take precedence over other considerations that would affect the time, place and nature of Conference meetings. The Western Forest Insect Work Conference at their meeting in Calgary in March concluded that concurrent meetings with our group could not be relied upon to increase attendance of either group at their respective meetings and could, in fact, have the opposite effect.

Organization. IV. Meeting locale

Recommendation 1: That the Conference conduct its meetings within the general area Victoria-Spokane-Portland, but that consideration be given to holding meetings beyond this area as special circumstances prescribe.

Recommendation 2: That the Conference rotate its meetings through the various centers of interest in such order that the burden of mass attendance will not fall on any one center for two consecutive meetings.

Comment: Those of the committee making Recommendation 1 felt that meetings should be held close to the center of the Conference population, thus facilitating maximum attendance. They agreed that although circumstances could justify meetings anywhere in the west, fringe-area meetings should require extraordinary justification. Those making Recommendation 2 felt that the Conference would not serve as an all-western organization by adopting a central versus fringe locale attitude now that attendance from fringe areas is so restricted.

Organization. V. Meeting frequency

Recommendation 1: That meetings be held regularly on an annual basis with some provision for changing the interval where particular circumstances demand it.

Recommendation 2: That meetings be held regularly on a biennial basis with some provision for changing the interval where particular circumstances demand it.

Recommendation 3: That the date of each subsequent meeting be decided upon in the business session of each meeting.

Comment: Probably the single most important consideration in deciding between Recommendations 1 and 2 is the volume of unexplored topics of discussion. Some members feel that the Conference has reached the point of diminishing returns with annual meetings. Most members feel that the Conference has in no way reached this point. Another important consideration is the effect of meeting interval on the time resources of the membership. It is possible, for example, that preparation for and attendance at annual meetings could prove to be too demanding upon the time of the membership. On the other hand, by changing the nature of our meetings the necessity for all members to attend all meetings would be less apparent than it is. There seems to be little factual evidence to show that meeting interval would directly influence attendance, i.e., biennial meetings would not guarantee greater attendance at any one meeting than would annual meetings.

Organization. VI. Meeting dates

Recommendation 1: That meetings be held regularly in the late fall with some provision for changing the season where particular circumstances demand it.

Recommendation 2: That meetings be held regularly in early spring with some provision for changing the season where particular circumstances demand it.

Recommendation 3: That the date of the next meeting be decided upon at the business session of each meeting.

Comment: The committee recognized that neither late-fall nor early-spring meetings would permit all qualified persons to attend for the reason that employment commitments vary among the membership. For information of those strongly supporting concurrent meetings with the Insect Work Conference it should be stated that they have decided to hold early-spring meetings henceforth (see Comment, Org. III.).

Organization. VII. Conference proceedings

Recommendation: That issuance of the proceedings of Conference meetings continue according to the format used for the third meeting and that distribution of them be made to all persons known to be qualified for membership and who have demonstrated an interest in it.

Comment: The committee was agreed that printed transcripts of our meetings serve a vital purpose in the conduct of Conference affairs. It was of the opinion, however, that a conscious effort should be made to alleviate the extraordinary volume of work that has fallen to the few members made responsible for this service each year.

Activities. I. Values

The committee's evaluation of the benefits that can accrue to Conference members and their sponsoring agencies, as the result of Conference activities, is presented in anticipation that it will stimulate an interest in the Conference by persons not presently taking an active part in it. Similarly, elucidation of these benefits is aimed at sustaining or increasing the interest of sponsoring agencies in Conference activities.

The committee agreed that other conferences that are open to participation by forest pathologists fail to meet the qualities of a work conference in that they provide neither the proper atmosphere nor sufficient time for discussion of forest disease problems. Hence, the role of a pathologist at such meetings is that of relating his work to other fields and, as such, is not conducive to improving his proficiency as regards the details of his work. A work conference, on the other hand, is committed to uninhibited discussion of disease problems and the ideas and techniques pertinent thereto and is, therefore, an admirable medium for advancing the calibre of forest disease research.

Some of the values to be derived from a forest disease work conference were considered to be:

1. Provision of an opportunity for personal contact and assembly of western forest pathologists beyond the local level and, consequently, for alleviation of professional isolation.
2. Provision for a pooling of ideas and points of view, some of which never reach publication and most of which would be made available long in advance of official publication.
3. Provision, through printed transactions of meeting proceedings, of a clearing house for notification of the initiation and completion of survey and research projects. Provision through the same medium of a continuing record of the accomplishments of different research agencies, contributions to panel discussions of selected topics, and an index of western forest pathologists and their affiliations.
4. Provision for investigation of a standard approach to and the manner of reporting on particular problems for the purpose of integrating the results of one project into those of a similar nature.
5. Provision for investigating the possibilities of cooperative action on problems of broad interest for the purpose of assuring effective participation by agencies having limited funds and personnel.
6. Provision for the further education and training of pathologists through the medium of group discussions involving persons having diverse and specialized background training.

7. Provision of a unique opportunity for educators to keep abreast with developments in forest pathology and, thus, an opportunity for them to constantly revitalize courses of instruction at universities.
8. Provision of an opportunity for administrators or research representatives of major agencies to gain an over-all acquaintance with research activities in forest pathology in the west.

Activities. II. Accomplishments.

In the process of making an appraisal of the benefits that might be expected to result from the Conference an opportunity was afforded to take stock of what has already been accomplished in its four years of existence. The comments of the committee in this regard are not offered as evidence in an attempt to justify the Conference but, rather, as a tribute to the unity of purpose that has characterized the Conference since its inception.

The most significant accomplishment of the Conference in its brief history, and one which has laid the groundwork for subsequent achievements, has been the creation of an atmosphere of mutual interest and cooperation among western pathologists. There is today, as the result of this fellowship, a free and informal passage of information and comment on all aspects of forest disease investigation. There are, however, more tangible achievements that have resulted from Conference activities and among these has been the formation of committees to undertake special work projects on behalf of the general membership. The specific assignments of these committees have been as follows:

1. To investigate the benefits that might accrue from the acceptance of suitable standards of measurement and analysis of data in decay problems.
2. To collect and evaluate the various methods employed and the results obtained from experiments on the chemical control of dwarfmistletoes.
3. To report, coordinate, and stimulate basic research on the physiology and ecology of dwarfmistletoes and their hosts.
4. To investigate the use of sample plots in studies of mortality and disease incidence.

The Conference has been instrumental in bringing university and industrial pathologists into its sphere of activities and, in so doing, has derived the benefits of its association with such persons. Similarly, university and industrial workers have been able to identify themselves with a group of research workers dedicated to the advancement of forest pathology principles. An initial contact has been made with interested persons in Mexico and an opportunity now exists to encourage forest disease research in that country. Realization of

such achievements has been facilitated by circulating printed transactions of Conference meetings and, for this reason, the evolution of meeting transactions into a well-documented record of Conference activities is in itself a noteworthy accomplishment.

April 1957.

R. E. Foster
 A. K. Parker
 W. W. Wagener
 J. W. Kimmey
 V. J. Nordin
 C. D. Leaphart
 L. S. Gill
 R. W. Davidson, Committee
 Members
 G. P. Thomas, Chairman

It was moved and seconded that this report be accepted with the thanks of the Conference, and that the committee, having completed its work, be dissolved. Motion carried.

Chairman Thomas proposed the following statement of Conference policy, based on the work of his committee:

A Statement of Policy Concerning Conference Organization and Activities:

- I. Objectives. To provide through discussion at a professional level a continuing opportunity for forest pathologists in western North America to exchange views on problems of mutual interest and concern to their field as regards research, survey, control, and extension activities.
- II. Values. Values that can be expected to accrue to pathologists and their sponsoring agencies as the result of Conference activities are:
 1. Provision of an opportunity for contact and personal assembly of western forest pathologists beyond the local level and, consequently, for alleviation of professional isolation.
 2. Provision for a pooling of ideas and points of view, some of which never reach publication and most of which would be made available long in advance of official publication.
 3. Provision through the printed transactions of meetings of a clearing house for notification of the initiation or completion of research and survey projects. Provision through the same medium of a continuing record of the accomplishments of different research agencies, contributions to panel discussions of selected topics, and an index of western forest pathologists and their affiliations.

4. Provision for investigation of a standard approach to and the manner of reporting on particular problems for the purpose of integrating the results of one project into those of a similar nature.
5. Provision for investigating the possibilities of cooperative action on problems of broad interest for the purpose of assuring effective participation by agencies having limited funds and personnel.
6. Provision for the further education and training of pathologists through the medium of group discussions involving persons having diverse and specialized backgrounds.
7. Provision of a unique opportunity for educators to keep abreast of developments in forest pathology and, thus, an opportunity for them to constantly revitalize courses of instruction at universities.
8. Provision of an opportunity for administrators or research representatives of agencies to gain an over-all acquaintance with research activities in forest pathology in the west.

III. Membership. Membership to be open to persons actively engaged in:

1. Research, survey, control, or extension activities pertaining to tree diseases or deterioration of forest products,
2. Administration of the activities listed in (1), and
3. University teaching of forest pathology or forest products pathology.

IV. Officers. Officers of the Conference to consist of a chairman and a secretary, elected by the attending members at the termination of each Conference meeting. The chairman-elect to be empowered to appoint persons from the membership to assist him and the secretary to conduct the affairs of the Conference.

V. Meetings.

Frequency. The Conference endorses the holding of annual meetings but will, on vote of the membership, change the interval between any two meetings when circumstances dictate that such action be taken.

Date. The Conference endorses the holding of late-fall meetings but will, on vote of the membership, change the time of any particular meeting

when circumstances dictate that such action be taken.

Locale. The Conference endorses the holding of meetings within the general area of Victoria, British Columbia -- Spokane, Washington -- Portland, Oregon but will, on vote of the membership, hold meetings beyond this area when circumstances dictate that such action be taken.

VI. Relationships with other groups. The Conference rejects in principle direct affiliation with other groups but endorses in principle concurrent meetings and joint sessions with other groups when such associations are clearly in the best interests of the Conference.

VII. Transcripts of meetings. The Conference will issue a transcript of each meeting, to be known as the Proceedings, following the format of the 3rd Conference transcript. The Proceedings will be issued to all persons known to be qualified for membership within the Conference and who have demonstrated an interest in its activities. To avoid any conflict of interests between the Conference, its members, and the sponsoring agencies of its members, each issue of the Proceedings will be prefixed by the following statement:

"The contents of these Proceedings are not available for citation or publication in whole or in part without the consent of the authors concerned."

VIII. Finances. The Conference will regulate its finances in such a way as to make each meeting self-supporting. Financial records of the Conference will consist, therefore, of an accounting of revenues and expenses pertinent to each meeting and shall be rendered during the business session of each meeting.

After a brief discussion from the floor, it was moved and seconded that this statement, as read, be accepted as Conference policy. Motion carried.

It was moved and seconded that Sr. Riquelme Inda's letter "be acknowledged with an expression of our sympathetic understanding of the difficulties facing Mexico on the launching of a forest disease research program, and also, that copies of Sr. Riquelme's letter be sent to Dr. M. L. Prebble and to Dr. J. R. Hansbrough for their information." Motion carried.

J. E. Bier briefly discussed the International Botanical Congress to be held in Montreal in 1959.

Election of Officers. J. W. Kimmey was elected Chairman of the Sixth Conference by unanimous vote.

H. R. Offord was elected Secretary by unanimous vote.

Sixth Conference Meeting. The consensus was that, subject to approval by the new Chairman, next year's meeting should be held in late fall in British Columbia.

The Conference extended thanks to the Portland and Corvallis groups for preparation of the meeting.

There being no further business, the Conference adjourned.

APPENDIX VI

PROVISIONAL MEMBERSHIP LIST
and guests at the Fifth Conference

(*indicates members and **indicates guests present at the Salem meeting)

- * Aho, Mr. Paul E., Div. of Forest Disease Research, U. S. Forest Service, P. O. Box 4059, Portland 8, Oreg.

- Andrews, Dr. S. R., Forest Insect and Disease Laboratory, U. S. Forest Service, P. O. Box 523, Albuquerque, N. M.

- * Bedwell, Dr. J. L., Div. of Forest Disease Research, U. S. Forest Service, P. O. Box 4059, Portland 8, Oreg.

- * Bega, Dr. R. V., Div. of Forest Disease Research, U. S. Forest Service, P. O. Box 245, Berkeley 1, Calif.

- * Berry, Mr. Dick, Oregon State Board of Forestry, 2600 State St., Salem, Oregon

- * Bier, Dr. J. E., School of Forestry, University of British Columbia, Vancouver 8, B. C.

- Bingham, Mr. R. T., North Idaho Genetics Center, U. S. Forest Service, Main St. and Taylor Ave., Moscow, Idaho

- * Blomstrom, Mr. Roy, U. S. Forest Service, 630 Sansome St., San Francisco 11, California

- Bourchier, Mr. R. J., Laboratory of Forest Biology, 102 - 11th Ave., East, Calgary, Alberta

- * Browne, Mr. J. E., Forest Surveys and Inventory Division, B. C. Forest Service, Parliament Buildings, Victoria, B. C.

- * Buchanan, Dr. T. S., Div. of Forest Disease Research, U. S. Forest Service, Washington 25, D. C.

- Burrill, Mr. Warren S., Bureau of Land Management, Roseburg, Oreg.

- * Bynum, Mr. Hubert H., Jr., Div. of Forest Disease Research, U. S. Forest Service, P. O. Box 245, Berkeley 1, Calif.

- ** Campbell, Mr. Robert K., Col. W. B. Greeley Forest Nursery, Box 172, Nisqually, Washington.

- Cannon, Dr. Orson S., Dept. of Botany and Plant Pathology, Utah State University, Logan, Utah

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- Chilton, Dr. J. E., Plant Pathology, New Mexico A & M College, State College, N. M.

- * Cummings, Mr. W. H., Weyerhaeuser Timber Co., P. O. Box 420 Centralia, Wash.

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- Prebble, Dr. M. L., Science Service, Dept. of Agriculture, Ottawa, Ontario

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