PROCEEDINGS OF THE 16th ANNUAL WESTERN INTERNATIONAL FOREST DISEASE WORK CONFERENCE

Coeur D' Alene, Idaho
October/November 1968

Proceedings of the 16th Annual Western International Forest Disease Work Conference

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FOREWORD

The Sixteenth Western International Forest Disease Work Conference was held October 28- November 1, 1968 at Coeur d'Alene, Idaho, U. S. A. The North Shore Motor Hotel served as Conference Headquarters. Meetings were held in the Hotel's Convention Center. Sixty-nine members and guests were registered.

The meetings were opened on Tuesday morning, October 29,by Chairman Stuart R. Andrews. Greetings were extended by Mr. J. F. Pehenec, Director, Intermountain Forest and Range Experiment Station, U. S. Forest Service, and Dr. Harvey V. Toko on behalf of Mr. Neil Rahm, Regional Forester, Region 1, U. S. Forest Service. The balance of the morning was spent in noting new and terminated projects, and with a special report by A. C. Tegethoff entitled "An interesting bark problem of lodgepole pine on the Targhee National Forest." Panel I, Diseases of Trees in the Inland Empire, was presented in the afternoon.

Five workshops, each attended by 10 to 15 members, were held Wednesday morning. Group leaders summarized findings at an ensuing plenary session. Panel II, Root Diseases and Intensive Forest Management, took place Wednesday afternoon. The Banquet was held that evening. The social achievment award was presented to Bob Scharpf, who led a group of hirsute companions in the entertainment of the evening. Neil Martin was the able M. C.

The field trip, which appeared to be in jeopardy from the wet weather of Tuesday and Wednesday, was held on Thursday. Although cool and overcast, all scheduled stops were visited. These included a white pine plantation in which blister rust control had been attempted by basal spraying with Acti-dione, a young stand of western larch infested with larch casebearer, and pole blight affected trees at Binarch Creek. After a sack lunch at the Priest River Experimental Forest Headquarters, Don Leaphart illustrated the root excavation phase of a drought simulation experiment intended to develop pole blight symptoms in white pine. The group then split up, with some inspecting the excavation, others various examples of root rot, and the remainder proceeding directly to the Forest Service Nursery at Coeur d'Alene. The return bus trip was via Spokane where smelter fume-damaged ponderosa pine were viewed. The information presented at this stop is reproduced as a special report by Gardner Shaw entitled "Flourine injury to ponderosa pine in the vicinity of Spokane, Washington." The business meeting was held in the evening.

Pannel III, Factors Governing the Distribution of Dwarf Mistletoe, took place Friday morning. Also presented was a report by K. R. Shea and J. L. Stewart on the West-Wide Program Analysis for Research and Development on Dwarf Mistletoe control. Four special reports by H. H. Bynum, R. D. Hungerford, Clinton E. Carlson and Harvey V. Toko, and D. E. Etheridge were given during the early afternoon. The conference was adjourned at 3 p.m.

Executive Committee

Stuart R. Andrews, Chairman
R. G. McMinn, Secretary - Treasurer

Program Committee

J. L. Stewart, Chairman
H. H. Bynum
J. A. Baranyay

Local Arrangements

D. Leaphart, Chairman
N. E. Martin
A. D. Partridge
H. V. Toko

Conference Historian

G. W. Wallis

OPENING REMARKS

Chairman Stuart R. Andrews

Ladies and gentlemen, old and new members and guests, it is my privilege to call to order the 16th Western International Forest Disease Work Conference. To those of us who first met in Victoria, British Columbia in 1953, this year's meeting is another link in the chain of research interest and international communion that has not been weakened by political or social change nor numerous re-organizations of parent agencies.

As one of the old men in the profession, I am impressed by the improving quality of forest pathology in North America. The subject matter and content of our Proceedings reflects this trend. It is particularly significant to note the increasing role of university and state-sponsored research in the West. A most beneficial by-product of this development has been the heightened quality of research by federal agencies.

I would also like to commend the contributions from those in our membership who are engaged in forest disease surveys and forest pest control activities--and other aspects that might be considered the art and practice of forest pathology. This plus recognition of forestry as multi-purpose land management is creating new and unexplored areas for creative research.

It is a great pleasure to have such a splendid representation from Canada. During this period of budget crises, it speaks well for careful planning and programming well in advance of the Work Conference.

On the other hand, I cannot help but share the disappointment expressed by last year's chairman, Alex Molnar, that none of our colleagues from south of the border will be meeting with us. Each year we have made special efforts to encourage their attendance. Yet since the last meeting in Victoria, our efforts have been unavailing. I propose that the question of future participation of pathologists from Mexico be discussed at our business meeting with the view to following a more active interim course.

This conference could not have been held without the great help of the Local Arrangements Committee and the Program Committee. Special thanks are due to Chairman Don Leaphart and the members of the Arrangements Committee. Early this year the committee chairman investigated possibilities within the

designated area and presented his recommendations for a meeting place. Once the selection had been made, your conference chairman was assured by frequent communication of a smoothly functioning operation. I am sure the Local Arrangements Committee will remain on-call throughout the meeting.

I wish to express special thanks to our Program Chairman, Jim Stewart. He accepted his assignment in mid-summer, when the demands of the field season would have caused most members to decline with thanks. Within a brief period Jim prepared an excellent program that included about half the subject matter suggestions submitted by Hart Bynum, the Interim Program Chairman at Santa Fe. The Program Chairman's greatest contribution, however, was in assembling an outstanding cross-section of our membership to present the program. To those members who agreed to participate, I also extend my thanks in advance.

This meeting has no special theme. Any one of the panel subjects could have been expanded to that purpose. But, in this year of transition, perhaps it is better that we broaden our scope to consider as many of our interests as time will allow.

Now it is my pleasure to introduce Joe Pechanec, Director of the Intermountain Forest and Range Experiment Station, and Harvey Toko, representing Neil Rahm, Regional Forester, Region 1 of the U. S. Forest Service, who will make the traditional addresses of welcome.

WELCOMING REMARKS

Joseph F. Pechanec

On behalf of the Intermountain Forest and Range Experiment Station, GREETINGS! Welcome back to another beautiful portion of this Station's territory. I'm extremely pleased that you selected Coeur d'Alene and that it worked out this year that I could meet with you again. I had the pleasure of attending your 1963 meeting in Jackson, Wyoming. This was both an educational and enlightening experience.

I would also like to extend our hospitality, including opportunities to see some of our disease research that is now in progress.

A work conference like this is excellent and essential. It fosters and stimulates the interchange of ideas, concepts, techniques, and even

practices on a broad geographic basis.

There are three thoughts I would like to leave with you. They aren't new or original. But maybe I can say them in a slightly different way or with different emphasis.

The first has to do with values involved or losses resulting from forest diseases. I would like to see disease research substantially expanded. But in 12 years as Station Director, both in the Southeast and here, I've been concerned with the discouragingly slow expansion we have achieved. We simply haven't been able to make convincing cases where it counts.

We've done much better with commerical tree species from a timber standpoint than with anything else. There may be two reasons--one is that timber is industrially and economically quantifiable, and the other is that our industrial and public forest land managers have had a longer period of indoctrination regarding tree diseases and timber values. The result is that our forest disease research is almost wholly oriented in this direction.

But even here we have not done as well as we should in coming up with some hard figures on mortality and growth impact. Part of this, I feel, is the result of no one wanting to accept responsibility. Less than a year ago I sat in on a meeting where the same question came up regarding insects. Forest survey, silviculture, and entomology men each said that this was not their responsibility or they weren't competent. I'm sure the same could be said of tree diseases. This inclination to have someone else take on the job needs correction.

Other values than timber are involved in losses from disease. If we had a better understanding of these they would add materially to the justification of present research programs aimed at timber production. Or they might provide justification for research programs that were more directly oriented toward recreation, esthetics, or wildlife habitat.

Quantification of these other values is a real enigma but there is considerable economic research going into this now. So maybe we can look forward to some help here. But there is an attendant knowledge gap fully as serious which falls right into the lap of the pathologist. We may not even know what is causing the losses, much less the significance.

The second thought is that pathologists, in common with scientists in other fields, must look ahead in formulating their research programs and anticipate possible disease implications of impending or future decisions regarding forest and range lands. Two specific examples may clarify this thought.

Concern about the rising level of air pollution and the resulting development of standards based on minimal knowledge could quickly close the door on prescribed burning. Wellner mentioned this at your meeting last year. What do we know, or what research is underway which would clarify the effect of large masses of organic material on disease incidence? Could the resulting change in soil flora increase the incidence of root rots? Are we alleviating one problem and intensifying another?

The second example is weather modification. As you know, weather modification for purposes of increasing snow pack is being vigorously and enthusiastically promoted as a panacea for water shortage in the Colorado River basin and elsewhere. The Ecological Society of America, based on existing knowledge which is meager to say the least, voiced real concern in their report about many side effects, including plant diseases. But what specific data do we have, or what research have we underway which could be included in a decision making process that could have far-reaching implications?

You and I, as well as many others, need to develop far better foresight in developing our research programs.

The two examples above provide a backdrop for my third thought, which is that we need to increase teamwork and interdisciplinary communication in our research programs. Gardner Shaw and Neil Martin last year made very thought-provoking statements to you regarding teamwork. I don't want to plow the same ground, but would like to use a slightly different approach.

There seem to be two opposing developments in forestry science today.

One is the narrow-and-deep trend that results from increasing specialization. Compartments become narrower. Technical jargon multiplies. Neither the desire to cooperate nor the ability to communicate is enhanced.

At the same time there is a growing awareness that side effects of any natural resource action or decision may be fully as important as the

the purpose for which the action was taken. This understanding is implicit in the concepts of multiple use, ecosystems, biomes, and the holistic approach.

Teamwork at some level between scientists in different disciplines is absolutely essential not only to produce solutions to some of the complex problems we face today, but to produce solutions that can be more readily applied by land managers.

The challenge lies with you and me, and many others, to find ways to develop and conduct more effective team efforts. There are in addition to disciplinary resistances, financial and organizational obstacles to overcome. But I'm convinced we must overcome them.

In closing, I'll repeat "WELCOME." I'm sure we can show you the hospitality needed to make this Sixteenth Meeting a memorable one!

WELCOME ADDRESS

Harvey V. Toko

On behalf of Neal Rahm, Regional Forester, I want to welcome you to the Northern Region. He regrets not being present but extends his greetings and the hospitality of the Region to all.

Since the last meeting of WIFDWC in the Inland Empire (Pullman, Washington - 1959), considerable progress has been made in the study of many forest diseases. Subsequent changes in forest management have resulted, although the acceptance of the work of pathologists by the land manager has often been difficult to attain. The most notable change in management practices in this area is related to western white pine. Results of surveys conducted in northern Idaho and western Montana showed that despite the ribes eradication program, infection by the blister rust fungus on western white pine is continuing at an average of 3 percent annually. The acceptance of these data by forest managers resulted in the curtailment of ribes eradication and the western white pine planting programs. The emphasis on the future of this species will be placed on the development of rust resistant strains. At present, the future looks highly promising.

Historically in the Northern Region, as in many of the inland

areas of the west, timber values, with the exception of white pine, have been low. However, this gap in price differentials has been equated over the past few years. As a result, management action has changed to include stands of the various coniferous species for future generations. With these changes, the land manager faces a dilemma. Little information is available on growth potential of the different species under various conditions or the disease problems that can be associated with this shift in emphasis. We are only beginning to get an insight into these various problems which undboutedly will increase as management is intensified.

Work conferences of this nature are important to all of us. Communication between individuals and the coordination of various projects should help us all receive the most meaningful information available. The subsequent acceptance and utilization of the research findings by the land manager then becomes the final phase of the project. However, close coordination must be maintained between the pathologist and the land manager to achieve this end and to make modifications or changes as new ideas are developed.

The potential of the Northern Region is beginning to be recognized from the standpoint of other resource values. The recreation and wildlife resources which include such phases as winter sports, hunting, fishing, hiking, etc., are expanding rapidly. The water availability is looked on by the drier southwest areas with envy and the possibility of development for a future resources for their use. Disease problems exist in recreation areas currently and undoubtedly affect the other resources adversely, but more information is needed for the land manager to better utilize these resource values.

I am proud of what we have in the Northern Region - abundant rivers and streams, large forested areas and, in general, the wide open space. You'll have an opportunity to see some examples on the field trip. In addition, I appreciate one of the things that we have only in limited quantities which many areas of the country have in ever-increasing numbers - that is, people. However, this will undoubtedly change rapidly, and it has already started - once the desirable aspects of the area are discovered by more and more individuals from the populated areas.

The companionship and esprit de corps which exists among the members of WIFDWC has impressed me since I attended the 10th anniversary

meeting in Victoria. Following the nightly esprit (spirit-in-the-corps), certain members see the following day's meeting through broken rose-colored glasses. The blood-shot eyes that are in evidnece would at least lead one to this interpretation. All of this is in good spirit, however, and I'm sure all of us will benefit as much from this conference as we have in past conferences.

PANEL I DISEASES OF TREES IN THE INLAND EMPIRE

Charles D. Leaphart, Moderator

INTRODUCTION

C. D. Leaphart

While there are those who believe that trees should exist for almost any use other than a timber product; e.g., paper, I would suggest that man, who is often classed as the defiler of our air, water and tree resources, would indeed be hard pressed to come forth with a substitute product in sufficient quantity of the type for which the Montgomery Ward and Sears Roebuck cataglogues were originally invented. When one seriously ponders the implication of that statement, I believe one would agree with me that diseases, other agents and/or management practices, which impair maximum productivity of many forested lands for wood fibre, merit serious consideration by the public today. Whether the diseases of trees in the Inland Empire can be controlled economically or even if they should be is, however, not the principal question to be resolved by this panel. Our aim is to acquaint you with those diseases of the Inland Empire region, which by our estimate are significant, and to discuss the on-going research on some of them.

Our interpretation of the boundaries of the Inland Empire is as follows:

> Starting at Lewiston, Idaho, draw the boundary NW (approximate) to Okanogan, Washington; then NNW to Kamloops, B. C.; NE to Jasper, Alberta; SE along the Rocky Mountain Crest through Glacier National Park and Montana to the Idaho-Montana border (South of Sula, Montana); then W to the Selway River and along it, the middle fork of the Clearwater River, and the main Clearwater River to the origin at Lewiston.

I think you will find that very rarely will a disease discussed today be unique to this region. Rather we suspect that you will use the knowledge provided here to broaden your concept of a disease or diseases with which you have been working. Toward this end, we have allowed time for discussion at the end of each presentation.

You probably have noted that the agenda does not list certain groups of diseases, particularly foliage and root diseases and those emanating from man's activities. In lieu of more authorative representatives, who for one reason or another do not appear before you on this panel, I'll brief those diseases that I estimate to be significant in management of trees for various uses.

Foliage Diseases. Like any region with a wide variety of conifers, the Inland Empire has quite an array of foliage pathogens, even excluding the rusts which Dick Krebill will cover. Why they seem to be ignored is to me a paradox in forest pathology. Only when they cause significant mortality, as for example by Elytroderma deformans which is hot spotted in our region, or affect a particular product of the forest, as Rhadbocline pseudotsugae is notorious for, through most of the Inland Empire, are foliage diseases prominent in our management curricula. Yet many, like Hypodermella concolor on lodgepole pine, Meria laricis and H. laricis on larch and H. arcuata on western white pine, essentially remain mycological curiosities, despite their periodic outbreaks resulting in considerable defoliation and attendant, though undefined, growth losses. Others like Lecanosticta acicola on western white pine and Dothistroma pini on ponderosa pine primarily, persist for several years' duration at intervals during the development of sapling and young pole stands and, thus, certainly impair the vitality of their hosts.

Root Diseases. What about them? We did not include these as a separate subject on our panel since they will be covered on one tomorrow. However, I do not know of a single important forest tree root pathogen in the United States and Canada that does not exist in the Inland Empire, except the Phytophthora root rots (and we may have them). For example, I hope other pathologists were more astute than I, but 10 years ago I thought the Poria weirii root problem of Douglas fir was important only in the coastal forests. I then found that many of the large holes in forest canopies in the white pine type were caused by this root disease. Two facts stand out here: namely, (1) my marked misjudgement based on fact and (2) insufficient knowledge. The first is probably incorrigible, but the second can and should be corrected for the benefit of our management people. A very significant step in this direction will be taken when the Pest Control Branch of Region 1 completes the root rot survey started this past year.

Non-parasitic Diseases. Really I am not trying to make our problems a drudgery to you, but I am impressed here with our wide variety of diseases related to environment, including man. Drought, like various forms of cold injury, is periodic; e.g., it was quite noticeable in certain areas in 1958, again in 1967 and, to a lesser extent, this year. While it resulted in death of parts or all of certain trees, its impact on the physiological well being of the remaining trees remains unstudied, unappraised and thus untold.

Because many of you may have a chance to see some of our local attractions, I mention our flourine damage from the aluminum reduction plants near Spokane, Washington, and Columbia Falls, Montana; our sulfur dioxide damage from the lead and zinc smelters at Trail, B. C., and Kellogg, Idaho, and the copper, lead and zinc smelter at Anaconda, Montana. Smog damage, as such, has so far not been publicized, although a few areas are notorious for their odors. But, with the coming realization of the high value of trees for purposes other than wood fiber, these types of damage represent a more significant problem than we have faced up to so far. I believe the sulfur dioxide damage, for example, is perhaps not so important for the tree death already effected, but for its imposition of a virtual biological desert for many years to come, even if air pollution were today completely stopped at the smelters. In fluorine damage centers it is quite obvious that pondersa pine, for example, will not be grown until the reduction plants are removed or their fume emission completely controlled. While this in itself imposes a long term effect of damage, other effects such as soil pollution, are less certain.

POLE BLIGHT: AN APPLIED RESEARCH PROBLEM AND A BASIC RESEARCH OPPORTUNITY

R. G. McMinn

Pole blight of western white pine (Pinus monticola Dougl.) for a time ranked high on the list of forest management problems in the Inland Empire. With annual losses estimated at some 21 million cubic feet (Davidson and Buchanan 1964), wood losses from 1930 to 1955 probably approached half a billion cubic feet. Assuming that no substitutes were

possible, direct losses could have reached more than $50 million from stumpage alone. Lost increment moreover has continued in many stands which remained virtually without growing stock since they were devastated decades ago. The advisability of further expenditures for blister rust control was also placed in doubt. Such losses and the alarming potential of pole blight warranted a substantial research effort.

Apart from its being of immediate concern to forest managers, pole blight was a basic research opportunity. Pole blight was an instructive, albeit costly, experiment. It was not the closely controlled experiment of molecular biology, but a perplexing large scale experiment useful nevertheless for the derivation of principles concerning that complex system, the forest. Pole blight was an opportunity to advance understanding of how forests grow and therefore how to grow forests.

HISTORY

Field studies to investigate the unexpected mortality of 40- to 100-year-old white pine which later became known as pole blight, date from 1938, when Erlich (1939) exposed the roots of 180 white pine in northern Idaho. Armillaria infections were found in 85% of these trees and Fomes annosus in another 13%. Heavily infected trees had shown growth reduction for 25 years. That the problem was something other than root rot however was apparent by 1940. By then, the disease was sufficiently widespread that Erlich and Baker (1942) reported difficulty in finding adjacent healthy trees for comparison. In retrospect, foresters familiar with white pine concluded that in Idaho, trees with appropriate symptoms were seen as early as 1927 or 1928 (Buchanan, Harvey, and Welch 1951).

Following a gap due to World War II, field studies were recommenced in 1947. With the development of a numerical index of symptoms (Buchanan, Harvey, and Welch 1951), disease severity could be rated and its progress followed on sample plots. In British Columbia, the northerly portion of the range of white pine, pole blight was first recognized in 1949 (Parker, Waldie, and Foster 1950), although trees had obviously been affected for some years previously. Recognition of the disease was probably delayed by the current preoccupation with blister rust.

A Pole Blight Investigations Steering Committee was set up in 1948 to maintain contact among the various individuals and agencies concerned with the problem. Initially progress reports were issued monthly, showing the urgency felt about the inroads this disease was making in a premium crop.

Intensification of the disease continued through 1952, but by 1953 the rate of symptom development seemed less than previously, and some trees even appeared to be recovering. By 1958, it was evident that the worst was over (Molnar and McMinn 1958). Although annual meetings of the Pole Blight Investigations Steering Committee continued until 1959, the Progress Reports ceased with the death of Dr. E. E. Hubert in 1954, as interest dwindled once it was evident that pole blight was not spreading into new areas and the rate of symptom intensification and mortality in previously affected areas was abating.

Although fresh lesions have continued to appear through the 1960's in some cases in stands with little if any previous incidence of pole blight, a re-survey in 1966 of plots established 5 to 8 years previously still showed no typical symptoms in 40 pole-sized stands. Certainly during the last decade, indicence is small compared with the 1930's, 1940's and the early 1950's.

DISTRIBUTION

The area affected by pole blight was large, perhaps some 100,000 acres in the United States Inland Empire (Graham 1958). Systematic surveys to determine acreages were not carried out in Canada. The sampling done to identify affected and non-affected sites and geographical subregions, however, indicated that pole blight was widely distributed in British Columbia.

Although pole blight occurred throughout much of the range of white pine in the Inland Empire, its distribution was not uniform. In Idaho, there was no appreciable incidence of pole blight in the southern portion of the white pine type, the area drained by the Clearwater River. In British Columbia, pole blight occurred less frequently toward the westerly margin of the range of white pine than in the central portion, along the axis formed by Nelson, Nakusp and Revelstoke. The upper altitudinal limit of pole blight was also lower than the upper

limit of white pine. Pole blight incidence toward the easterly and northerly margin of the range of white pine in British Columbia was not investigated.

From the forest management viewpoint, these discontinuities in distribution offer an opportunity for selecting areas which may be of low hazard for pole blight. From the scientific viewpoint, such anomolies are significant in developing pole blight as a model of forest disease.

SYMPTOMS

The symptoms of pole blight may be summarized as follows:

1. Trunk (and root) lesions.
2. Reduced radial and height increment.
3. Reduced crown density, particularly in the upper crown, which resulted in a dieback pattern.
4. Reduced needle length, reduced time of needle retention and chlorosis of needles.
5. Dead roots and rootlets, with dead vertical roots a consistent feature.

Buchanan, Harvey and Welch (1951) concluded that lesions (streaks of dead cambium occurring on the main bole) were the only symptom that could be considered specific for pole blight. The pole blight syndrome, however, seemed insufficiently diagnostic to indicate the origin of the disease.

CLIMATE

Climatic variation in geological time has been enormous. At one time tropical plants grew in the Arctic, at other times Canada was under several thousand feet of ice. Although not of such proportions, there is evidence of change within historical time. In Britain, for example, the disappearance of vineyards has been related to a progressive cooling trend from 1300 to 1850 (Lamb 1965). On the other hand, during warm intervals, for example the period around the 1530's, upland areas could be used for arable crops such as wheat. With the return of cooler weather, hillside farms were abandoned with significant economic and political consequences.

In western North America, historical records which indicate

climatic change do not go back so far. Marshall (1927), nevertheless, reports that Capt. Clarke noted in his diary during 1805 that the day is "cloudy as usual". In the 2 years that the Lewis and Clarke expedition spent in Montana, no forest fires were encountered. Capt. Bonneville, on the other hand, was impressed by the vast fires raging in Oregon during 1834. These records agree with Marshall's dendrochronological evidence that the periods 1786-1825 and 1845-1855 were wet, with the intervening period being drier. His conclusion was based on the assumption that growth rates in white pine are enhanced by increased moisture during the growing season and visa versa. This assumption was affirmed by Zahner and Stage (1966), who noted the predominant influence of moisture stress on the growth rate of white pine.

Leaphart and Stage (1969) found from their dendrochronological studies of white pine that although years of poor growth have occurred before and they are frequently clustered, the sequence of negative departures from the normal growth rate that began in 1916 was the largest and longest in 280 years. Consequently many pole-sized stands which became established during the period 1853-1882, which Leaphart and Stage considered favorable for growth, experienced exceptionally dry conditions when they reached 40 to 80 years. Bray (1965) concludes that a period of high sunspot activity began in 1914. Such periods are correlated with warm temperatures, glacial stagnation or retreats and changes in tree-growth rates. He also considers that current conditions may be similar to those prevailing before the cooling trend began 6 to 7 centuries ago.

While instrument records in the Inland Empire are relatively short, they do show that a prolonged succession of hot, dry summers occurred in the 1920's and 1930's. The onset of pole blight coinciding with this period provides circumstantial evidence that its incidence was related to climatic change, particularly moisture stress. A reduction in the frequency of droughty summers during recent years affords an explanation for the subsequent decline in pole blight incidence (McMinn and Molnar 1959).

The intensity and duration of drought periods was not uniform throughout the range of white pine. At the Pierce Ranger Station in the Clearwater drainage, for example, decreases from normal rainfall during

the dry years 1916-1940 (Leaphart and Stage 1969) were less than elsewhere in the Idaho white pine region. This less extreme moisture deficit could provide part of the explanation for the low incidence of pole blight in this region. Several stations had a bimodal distribution of drought years (Powell 1965 a, b). Such a distribution may account for the development of lesions during distinct periods (McMinn 1969).

SOILS

Viewed in context with this climatic sequence, soils prone to drought should be those most conducive to pole blight. In Idaho, Leaphart and Copeland (1957), in fact, found that the average depth of available moisture in the top 3 feet of soil in diseased stands was 3.32 inches. None had over 5 inches. On the other hand, healthy stands were characterized by having more than 5 inches of soil moisture storage capacity or were in topographic positions allowing soil moisture recharge during the summer season. Low soil moisture storage capacity and recharge potential accounted for 70% of the pole blight incidence in an analysis which included ground cover plants, basal area of all trees species, site index and soil depth (Leaphart 1958). The low incidence of pole blight in the Clearwater drainage may well have been related to the considerable depth and the lack of stoniness of soils in this region which assured large soil moisture storage capacities.

In the northerly portion of the white pine range, in British Columbia, on the other hand, soils with small storage capacities were just as frequently without pole blight as they were with it. In view of the evidence from Idaho that pole blight incidence was well correlated with low soil moisture storage capacity, the absence of pole blight in some moisture deficient soils is thought to result from an amelioration of the effects of drought or lack of susceptibility of trees. It is not interpreted as a negation of the role of drought in causing pole blight where it did occur.

PATHOGENS

Although considerable effort was expended investigating the role of pathogens in causing pole blight, none were demonstrably the

primary cause (Leaphart and Gill 1955, Parker 1957). This may, of course, be a tribute to the subtlety and inscrutability of such organisms, rather than proof of their non-involvement.

INSECTS

No primary causal role in the development of pole blight has been demonstrated for insects (Hedlin 1956). The presence of Europhium trinacriforme (Parker 1957) might be explained by an insect vector, but so far none has been revealed. Root weevils were present, but a primary role in the decline of pole-sized trees was not ascribed to them.

It is probable that in British Columbia more white pine were killed by mountain pine beetles than by pole blight. However, it is likely that fewer pine would have been attacked had pole blight not occurred. Pole blight was probably a predisposing factor to both successful beetle attack and the buildup of beetle populations which occurred in many white pine areas. Concomitant weather conditions favorable to the successful completion of insect life cycles may also have been contributary. It is noteworthy that many successful mountain pine beetle attacks occurred up to 15 or more years after trunk lesions had developed and their margins callused.

INTERIM SUMMARY

There is evidence, direct instrumental and indirect dendrochronological, that a sequence of hot, dry summers occurred during the present century. The degree of adversity for white pine and the timing of these drought years coincide plausibly with the onset and duration of pole blight. The prevalence of pole blight on soils deficient in moisture storage capacity reinforces the likelihood that a climatic vicissitude of major proportion initiated pole blight.

In some instances, the absence of pole blight in soils with small moisture storage capacities can be related to the favorable soil moisture regime to be expected toward the upper altitudinal limit of white pine, and in others with the soil nutrient regime characteristic of weakly leached soils (McMinn 1965). These factors do not account for the absence of pole blight in many other droughty soils.

INTRA-SPECIFIC VARIABILITY

Pole blight generally affected dominant white pine. While the greater crown exposure of dominant trees might result in their being more subject to moisture stress than intermediate trees, the infrequency of pole blight among intermediate trees even in open stands, suggests that crown stature alone was not the differentiating factor. Differences among trees may, in some instances, provide an explanation for the occurrence or non-occurrence of pole blight. Four stands are used to illustrate the evidence for this belief.

The first example is taken from Mackinson Flats, two square miles of pole-sized white pine growing on a sandy terrace. Throughout most of the Flats, pole blight was so prevalent that Mackinson Flats became virtually synonymous with the disease. Near its southerly margin, however, few pine died. Although the texture of the sand in this part of the Flats was finer than elsewhere, soil moisture storage capacity still seemed small. Stand composition and the size of the white pine were the most striking differences correlated with the difference in pole blight incidence. Throughout most of the Flats, the dominant white pine were relatively large, aspen were common and hemlock rare. Although similar in age, the white pine toward the southerly margin of the Flats were slender, aspen were rare and the bulk of the stand consisted of a dense stocking of immature hemlock. In most places, the fire which had preceded the immature stand which covered the Flats had burned sufficiently hot to remove all the litter and produce "old field" conditions. Toward the southerly margin of the Flats, the fire must have died out as it reached the mature hemlock stand which bounded the terrace at this end. Some litter may have remained. During regeneration after the fire many hemlock became established in this favorable seed bed, with the adjacent mature stand providing a nearby hemlock seed source. This mature stand also contained a few veteran white pine, which could have been the seed source for the white pine toward the southerly part of the Flats. The white pine which became established adjacent to the mature hemlock stand differed from the dominant and co-dominant white pine growing elsewhere on the Flats in having grown more slowly. This difference may have been a phenotypic response to competion

from the dense stocking of hemlock which comprised most of the stand. It might, however, have been genotypic because these white pine were probably derived from a special seed source, the white pine which had survived in the mature hemlock stand nearby. Throughout the remainder of the Flats, the dominant white pine grew rapidly. It was these fast-growing white pine which succumbed to pole blight. Among the slow-growing white pine at the southern end of the Flats, there was virtually no mortality, although trunk lesions were quite common.

The second immature white pine stand which had no mortality from pole blight, despite its soil having a low moisture storage capacity, was on another sandy terrace, opposite Mackinson Flats. In this case, the pole-sized white pine which constituted an "island" in a "sea" of mature hemlock probably originated following a small spot-fire. This fire may not have destroyed all the litter which then formed a seedbed favorable for hemlock, the major constitutent of the stand. The few white pine were slow growing. Trunk lesions had occurred in the 1920's, when these trees were some 80 years old. These lesions, however, had callused and all the white pine were living when the stand was sampled in 1966. The mature hemlock stand surrounding this immature stand included a few veteran pines. These pine are likely to have been the seed source for these apparently pole blight resitant white pine.

The third immature white pine stand which had no pole blight was similar to the second, consisting of an island of pole-sized white pine surrounded by mature hemlock. Its soil had limited moisture storage capacity because the average depth of soil to the underlying basal till was only 2 feet. A favorable soil nutrient regime is unlikely to have been the ameliorating factor because the profile was strongly podzolized. Although the secondary canopy of hemlock in this stand was not dense, the white pine were slender and slow growing.

The soil of the fourth immature white pine stand was likewise a podzol underlain by basal till only 2 feet beneath the soil surface. No pole blight had occurred despite this limitation on soil moisture storage capacity. Although on a south facing slope, the moss layer was thick and the litter layer deep, suggesting that the fire which preceded stand establishment was not intense. Seedbed conditions

may have favored a subspecific variant of white pine unlike those commonly found on other south-facing slopes.

It seems probable that the slow-growing white pine in these four stands were different from those in fast-growing stands where pole blight was a more consistent feature. Perhaps, in some cases, they were phenotypically different because they had greater competition from hemlock. Perhaps they were genotypically different, being derived from the few veteran white pine present in adjacent mature hemlock stands. Such white pine had survived previous beetle infestations, mini-blights and other forms of attrition to which pioneer trees are exposed. The immature white pine in these non-affected stands might also be a selected type different from those thriving on south slopes and "old field" conditions because a shaded seedbed, with thick litter layers, might allow only certain genotypes to survive. Old field conditions which follow intense fires may promote the establishment of other genotypes.

What then is white pine's survival strategy and how might it be related to pole blight incidence? In the northerly range of white pine, this species can exploit severely burned areas and survival rates are high enough to produce well-stocked stands even on relatively bare and exposed seed beds. If, within a hundred years or so, another fire occurs, a similar stand begins again because an immature white pine stand is likely to burn, leaving exposed mineral soil suitable for the re-establishment of white pine. On the other hand, if no fire occurs for 300 to 400 years, beetles and other forms of attrition would gradually eliminate the pioneer white pine, leaving an overmature hemlock stand. When a fire does occur, its effects would probably be less intense among widely spaced veteran trees than among highly inflammable immature white pine. The new seed bed would probably not consist of bare mineral soil and some shade might even be present. White pine's strategy for survival should therefore include some types which can survive as long as hemlock. They should also be moderately shade tolerant so that their seedlings can grow under the seedbed conditions which might prevail when the overmature stand burns. We might distinguish between a Type A and a Type B white pine, with which the species hedges its bet for survival. Following an intense fire, Type A

will predominate; following a light fire, Type B might be the most common. Obviously any stand is likely to be comprised of a mixture, but one type may well predominate. The response could be largely phenotypic. Intra-specific differences are a likely explanation for some of the anomalies encountered in pole blight incidence in British Columbia. Type B, the type presumed to thrive under shaded conditions, might concomittantly be less susceptible to pole blight than Type A.

If, as seems to be the case, there are differences in pole blight incidence between British Columbia and Idaho, the explanation may lie in differing frequencies of these putative types of white pine. Since overmature hemlock stands are relatively infrequent in northern Idaho, because fires occur with sufficient frequency for white pine stands to follow white pine stands more or less indefinitely, the survival strategy of white pine may not include an appreciable proportion of Type B. Consequently, drought and limited soil moisture storage capacity may explain most pole blight occurrences, and the absence of pole blight could be correlated with the absence of these factors. In British Columbia, many stands which start as white pine/hemlock mixtures remain unaffected by fire long enough to be transformed into overmature hemlock stands. Without long-lived types, white pine might be less frequent than is currently the case in the wet interior belt of British Columbia.

Such an explanation is readily appreciated only when a wide range of conditions is studied, regardless of political boundaries or other constraints. Had the small, inconsequential patches of white pine surrounded by overmature hemlock been overlooked, or the population dynamics of white pine and hemlock in the Interior Hemlock Zone been ignored, the evident importance of intra-specific variation might not have been apparent. The occurrence or absence of pole blight seems to act as an index of such variation.

CONCLUSION

What then may be learned from pole blight as a forest disease model? Since trees have relatively long life spans between establishment and harvesting, they may be exposed to climatic vicissitudes which exceed the tolerance of some individuals. Remedial measures such as irrigation,

fertilization or pesticides are not likely to be as feasible as they are for field crops. An alternative strategy is sufficient diversity to ensure the survival of adequately stocked stands. Unfortunately the ability to withstand the amount of drought which seems to have initiated pole blight seems to have been accompanied by a slow rate of growth. In view of the considerable economic advantage of rapid growth, the stability which may be gained by a slow rate of growth must be balanced against the chance that a similar climatic vicissitude will occur before trees can be harvested. In view of the magnitude of the climatic adversity thought to have initiated pole blight, a reversal of such proportions seems sufficiently improbable that it may not be necessary to forfeit the economic advantage of rapid growth to obtain protection from pole blight. We may furthermore assume that if such a climatic reversal is repeated, improved access to affected stands and improved forest products technology will enable use to be made of threatened crops even while they are at a small size.

Pole blight, however, is not the only problem. Our overall strategy for growing trees should not overlook the strategy that has served organisms for millions of years - DIVERSITY. It would seem prudent to identify the diversity in tree populations and maintain gene banks of these diverse characteristics. Then, even while we concentrate on fast growth, we shall not have precluded alternatives in the event of future disease situations which will surely come.

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INLAND ROTS AND TOMMYROTS

A. D. Partridge

What I have to discuss is not all fact - rather, it is a series of impressions from people I meet - woodsmen, loggers, some students and occasional pathologists. I hope not to sell you a point of view concerning decays, but to generate some awareness of problems in our area.

In this "Inland Empire", sometimes defined as an indiscrete and partly undelimited but vaguely bounded land mass centered almost precisely in southern British Columbia or northern Idaho, we periodically encounter a deterioration of trees known as rot or decay - as you prefer. Such decays are not always separated easily from one another, but their causes can be conveniently pigeon-holed. And so we pretend

that they are primarily mycological. This absolves us, as pathologists, from any appreciable responsibility. Mycologists, being magnanimous, describe a few rots as incidental to descriptions of associated fungi; and occasionally the rot and associated fungi are really related. Obviously, this is convenient and useful because it frees pathologists for "more scientific approaches." As a result of the ensuing almost accidental attention to decays, some vocal, agitative, minority groups like loggers, lumber men, wood-working tradesmen, cruisers and others voice a weak agitation. Such dissatisfaction is clearly unfounded. Everyone knows the major decays have been described to almost undeniable perfection for decades in publications like the Idaho Scaling Mannual. Of course, these are not necessarily up-to-date, they do not contain much for the cruiser, nor is there a complete description of all decays, and there are some other minor inadequacies; but these publications are nonetheless useful. Incidentally, of the published discussions concerning decays, few except the scaling mannuals emphasize the appearance of the decay itself rather than the form of associated fungi.

Can't use these descriptions in the woods, you say! Why not? Man - you've got to work on it! A few years of experience usually help - and you probably need more schooling. It's all in the literature somewhere. You "gotta" search a little!

More photographs? These are costly to publish. Besides, when these descriptions we have were written, photography was difficult, unreliable and inexact. And you know, too, that photographs can lie.

Compare the decays? What do you mean, they're all different! Oh, you mean the fungi have been compared! Well, I don't know. Probably we'd never achieve the 99 percent statistical accuracy so essential to acceptance by the modern scientific world. Even though you foresters don't need this accuracy, we pathologists must maintain professional status. Anyway, tradition places Fomes pini first as a decay fungus becuase of its universal appearance in softwoods across the continent. Then it's only logical to discuss others in order of their impacts. Perhaps this seems irrational and disorderly but we must work within the pattern of traditional training that pathologists receive. Remember, it's much easier for you to use the conks for identification

and more accurate too. You often can't find conks? Well, you're working during the wrong season. If you cruise during late September and early October, you'll find most fungi fruiting. The whole thing is quite easy - you merely use the rules we give you.

Help! How can I help you any more - you're the field man. We've written down all we know. Perhaps that's not much but we don't have enough time and money as is. Contact your legislator. Get our appropriations expanded.

Ridiculous? Or are these comments really so far from true? This seems to me an exaggerated parallel of the picture of decays we present to the subscribing public in the Inland Empire. Instead of serving people we tend to satisfy our individual interests when it comes to decays. There are available keys to mammals, birds, insects and mushrooms of the northwest - but what about decays? And is this surprising. I find that even professional foresters; that is, college graduates, are almost uneducated in this realm, probably because most forest pahtology courses have been mycologically, not pathologically, oriented.

Eight years of work on decays in the Inland Empire indicate to me that our literature is, for the most part, repetitious, contradictory and unorganized. Much of its content is observational and, therefore, half-truth although provided by sincere, early workers who did not possess the sophisticated means that we now have. Thus, the primary or at least the most frequent of pathological problems in forestry - decay or rots - have been treated almost perfunctorily in the eyes of our customers, the public. That is, in the Inland Empire we have apparently almost as much tommyrot as wood rot.

Let's look at some specifics. Keep in mind, too, that I am not discussing an even larger loss by decays in logs, fence posts, poles, lumber, slash and other wood in service, but I will remain confined to standing confiers. And I emphasize those decays that our surveys indicate are frequent in Idaho.

The first decay by Echinodontium tinctorium, the Indian Paint Fungus, alone or in concert with other fungi - and I say this latter because even causal relationships for many of these fungi are poorly

established - is described almost consistently in the literature as yellow-brown, stringy, with occasional red streaks or flecks. Both in trees and in laboratory cultures of the fungus in wood, we find the decay ranges from a yellowish buff, stringy mass to a very light brown, somewhat firm and laminate mass, and it may include white or reddish mycelial felts, or it often does not have any red at all.

The firm form of this decay looks good until it hits the saw. Additionally, we don't find conks consistently associated with determinate amounts of decay as implied by the literature. We often do not find the 16 feet of cull in either direction that we should. We have recorded cull associated with a single conk that ranges from a thin 9-foot column to a completely destroyed heartwood 68 feet long. And in many instances we find trees without sound heartwood that have no conks visible. The discrepancy here is apparently not a result of poor work but of applying data from a few species to many, and of using information on old growth in stands that are now mostly second-growth timber. In any case, the data which are written do not adequately fill the needs of our area. The error in using published cull factors for susceptible species in this case ranges from 72 percent less than indicated to 80 percent more. This kind of error can cost the small operator, who incidentally is an important part of our northern Idaho population, his entire profit or even his job. And another thing about this decay: laboratory tests indicate considerable strength loss even in incipient stages, but imply that the decayed wood produces fair to good pulp. What about this? Is all decay a loss? Are we, as our "pathological creed" implies, increasing timber volume by reducing loss in every possible way? If we are, it's poorly publicized. This decay, in Idaho, is probably first in terms of volume loss and frequency principally because of the dominance of grand fir and hemlock both in residual and second-growth stands. We have an obligation here!

More about this utilization aspect. Cull figures, the few that exist, for columnar rot of cedar by Poria asiatica (Polyporus sericeomollis) indicate frequent total loss of invaded trees. Yet we have shell-log markets in Troy, Bovill and St. Maries, Idaho where these logs bring $35 to $45/M bd. ft. Our pathological minds don't seem attuned to the real changes in both utilization and management

intensity that exist in forest industries. Such facts rarely appear in pathological literature. Perhaps we've lost touch with the people who should benefit from what we can tell them. Or maybe they've just quit listening to our windy discourses on molecular biology, numerical taxonomy of fungi, subterranean microbiological ecology, etc.

Much of the literature conveys the impression that conks or any fruiting bodies constitute the best of diagnostic means, and this is true. But in our area infrequent, or perhaps rare, fruiting occurs on live trees affected by Hydnum abietis, Polyporus sulphureus, Armillaria mellea, Fomes roseus or subroseus, Fomes nigrolimitatus, Polyporus oregonensis and even Poria weirii. Also, there is a differential response to substrates. Poria weirii fruits commonly on cedar, but rarely on Douglas-fir or grand fir, although the decay is not unknown in these species.

There are decays of considerable consequence that are hardly mentioned as occurring in our area. Moreover, these decays are poorly described, if at all. Decays by Polyporus resinosus (a soft, white rot with almond odor), Polyporus borealis (a white, small-cubed rot particularly of Engelmann spruce), Hydnum (Hericium) spp. (long, empty pocket rots), Polyporus leucospongia (a light-brown rot of high-elevation timbers), and Stereum sulcatum (a slimy, soft white rot) can be so rated.

And there are decays that go unrecognized, because they haven't received attention, although they have been described. Trametes heteromorpha is a primary agent of sapwood decay in pines causing a rapid, brown, cubical rot. In fact, a legal case here in Doeur d'Alene centered on this decay recently. And Coniophora puteana leaves hollow butts in high-elevation spruce and lodgepole pine. There are others, including Corticium glactinum which cause a finely fibrous, yellow rot, and Polyporus versicolor which causes a uniformly white rot.

Some individual decays have been well described for other areas or regions of our continent, but the descriptions don't hold here. Our records of this year for 86 plots in northern Idaho indicate Armillaria mellea frequently, if not always, causes a fine pocketing of wood prior to the "whitish, soft and spongy or stringy" conditions described so often in literature. And Polyporus versicolor, mentioned

above crops up frequently as a cause of conifer decay although usually it is described for hardwoods.

Some decays are almost impossible to separate in the field except by substrata and probability tables. Those caused by various species of Pleurotus or by Fomes laricis and Polyporus sulphureus fall into this category. How many probability tables of this type are available?

What about the way rots have been named? Decay by Echinodontium tinctorium has been called: brown, stringy rot; stringy, brown rot; punky rot; hemlock rot; yellow-brown heartrot; and yellow-brown, stringy rot. Decay by Fomes pini has been called ringrot, ring scale rot, white-pocket rot, white speck, conk rot, red heart, honeycomb, and pecky rot. How in the world can order exist when even the names of these decays are so haphazardly derived?

It seems to me that all this indicates insensitivity in recognizing decays as a real problem in forest communities. This is not cured by more people or more money. Our cognizance alone will help.

An so, what can we do? First, let's name these decays logically and descriptively so that we and our readers know what we're talking about. Names like "pointed, white-pocket rot" (by Fomes pini), "large, white-pocket rot" (by Fomes nigrolimitatus) and "pointed, hollow pocket rot" (by Hydnum abietis) seem to separate and describe decays.

Then it seems to me we should develop simple, workable keys and correlative descriptions for all decays in our areas, make these understandable to foresters, loggers or what-have-you. This can be done in spite of what you may have been led to believe. It can be based on substrates, gross characters of the decay, and correlated with signs of causes. But keep in mind that no key will work to 100 percent or even 99 percent perfection, particularly under field conditions. The rough draft of a key used in teaching forest pathology, which has been handed to you, was used by approximately 180 students, foresters and woods workers during the past two years. This key is restricted to the Inland Northwest. Even in this rough form, the users experienced an average accuracy of 83 percent. This is a start - one that can well experience considerable revision.

Then we can attempt to correlate decays with external site and tree characteristics including ecological types and physiographic features.

Such information forms the basis for probability tables and can serve in rotation estimates. Our recent research and that of others implies relationships exist between decays and ecological union, aspect, slope, soil type, rainfall, latitude and elevation. Some of these are clear, others are obscure, but they constitute useable working tools for estimates and can be computer-analysed.

Instead of the single-tree concept for estimating cull, we should perhaps consider stand condition, density, fruiting bodies per acre and similar criteria for cruises, particularly in our area where signs are not a common part of the decay complex.

Yes, there's much we can do - and in so doing perhaps we will gain the support we need to go further. But first - before doing anything - we need to think, look, and tune our hearing to people's needs rather than bow in submission to ancient dogma.

NATIVE RUSTS OF THE INLAND EMPIRE

R. G. Krebill

Within Leaphart's boundaries of the Inland Empire there are numerous native rust fungi attacking forest trees. Many of these attack only foliage and rarely cause more than minor damage. The stem rusts are more striking, but fortunately they are not capable of attacking most of the more economically important tree species. Even so, native rusts must not be neglected since many are potentially dangerous in at least local situations. In the spirit of enlightenment, I will attempt to make a brief analysis of the rusts native to the "Empire." I rely heavily on Ziller's 1953 check list and specimens at Washington State University (WSP) for this paper.

Gall and Canker Rusts.-- In the Inland Empire, native gall and canker rusts attack hard pines and juniper. Western gall rust is the most abundant and conspicuous of this group and commonly attacks lodgepole and ponderosa pines throughout the Empire. In Coeur d'Alene and many other places, western gall rust may be found in greater abundance on ponderosa pine than on lodgepole pine. However, south of the Empire, this rust is more frequent on lodgepole. Is this a difference in the hosts, the fungus or simply the environment? Another point for discussion

is life cycle. While we now find only autoecious Peridermium harknessii in the Empire, it was at nearby Haugan, Montana that Weir obtained a pine-to-Castilleja alternating form. Autoecism apparently is possible because of the ability of germ tubes to produce uninucleate cells rather than dikaryotic (Hiratsuka, Morf, and Powell 1966). At our Logan Lab, Christenson confirmed the uninucleate condition of germ tubes, but we have been unable (even by electron microscopy) to confirm a process of meiosis involving nuclear fusion. Epidemics of gall rust in the Empire have been frequently noticed. Leaphart (1955) and Peterson (1967), indicate that gall rust is maintained in pine stands by an abundance of new infections every few years. Environmental conditions favorable for infection can surely be expected to continue to favor spring infection and we must expect this rust to be an increasing problem as management of hard pines intensifies.

Being restricted mostly to lodgepole pine, stalactiform rust is less common than gall rust but still causes severe defect locally throughout the Empire. Being heteroecious, it requires conditions for pine infection later in the growing season than does western gall rust. Even so, the environment of the Inland Empire is frequently favorable, judging from the abundance of cankers of all ages in many sites. One of the few attacks of ponderosa pine was recorded east of here in 1915 at the Savenac Nursery, where more than 4% of the seedlings were found infected by Peridermium stalactiforme. We know far too little about the rust, for surely it will be an important factor in intensive management of lodgepole in the Empire.

Comandra blister rust is probably more localized but is distributed throughout the Empire on both ponderosa and lodgepole pines. Here it alternates both to bastard toadflax and northern comandra. Because it occurs on drier sites, bastard toadflax is usually involved in alternation to ponderosa pine while both bastard toadflax and northern comandra are concerned with Cronartium comandrae in lodgepole pine. Northern comandra is also limited in the States by its distribution restriction to along the Idaho-Washington border to as far south as the Clearwater River. Although most years apparently are not favorable for pine infection, epidemics are more frequent here than they are further south. In the Empire, comandra rust is probably less of a threat to

lodgepole than western gall rust and stalactiform rust but it will continue to cause local damage to both lodgepole and ponderosa.

Of no economic concern are the Gymnosporangium rusts causing necroses of stems of Rocky Mountain Juniper. These include the globose gall rust caused by G. nelsoni, the knotty gall rust caused by G. bethelii, and the stem necroses caused by G. inconspicuum. These alternate to juniper from leaves and fruits of hawthorn and serviceberry.

Broom Rusts. -- Witches' broom rusts occur throughout the Inland Empire, but seldom are abundant enough to cause concern. This is fortunate since they can reduce tree growth, provide infection courts for heart rots and even kill trees. Grand and subalpine firs are infected in Spring by basidiospores of Melampsorella caryophyllacearum originating on the chickweeds Cerastium and Stellaria, while Engelmann spruce is infected by Chrysomyxa arctostaphyli basidiospores originating on kinnikinnick. Brooms on Rocky Mountain juniper are caused by Gymnosporangium nidus-avis which alternates from serviceberry.

Cone Rusts. -- Cones of both spruce and true firs are occasionally attacked by rusts in the Empire. Chrysomyxa pirolata infects Engelmann spruce cones and alternates to Pyrola and Moneses. Fir cones are more rarely infected apparently by Pucciniastrum epilobii. Little is known of the effects of cone rusts on tree regeneration but they are probably less troublesome than insects and other parasites.

Foliage Rusts. -- Rusts attack foliage of many kinds of trees in the Inland Empire but generally cause little more than minor damage.

Needle rusts of true firs are frequent and can cause significant defoliation. Those forming white aecia in firs include Uredinopsis pteridis and Uredinopsis longimucronata, var. longimucronata; both alternate from ferns. Orange aecia form on fir needles attacked by Pucciniastrum goeppertianum (alternates from Vaccinium), Pucciniastrum epilobii (alternates from Epilobium), Hyalopsora aspidiotus (a fir-fern rust), and Melampsora epitea (which alternates from willows). Others are probably present since several likely rusts are known in the Empire on alternate hosts.

Spruce needles also are frequently attacked by rusts, and defoliation in local areas sometimes is severe. Distribution is closely tied to occurrence of alternate hosts except for Chrysomyxa weirii which

short cycles on spruce needles. Ledums are thus necessary to outbreaks of Chrysomyxa ledicola and varieties of Chrysomyxa ledi, and Empetrum is necessary for attacks by Chrysomyxa empetrum.

Lodgepole pine needles are frequently attacked by Coleosporium asterum which alternates from Asters and Solidago. A less damaging needle rust, Peridermium weirii was found in needles of lodgepole pine in nearby Kooskia, Idaho; this might be the alternate stage of the Senecio rust Coleosporium occidentale.

Hemlock needles are attacked by a form of the willow rust Melampsora epitea and the Vaccinium rust Pucciniastrum vacanii.

If larch escapes the casebearer insect, it still must contend with the willow rust fungi Melampsora medusae and Melampsora paradoxa.

Even mighty Douglas fir doesn't escape rusts in the inland Empire. Both Melampsora albertensis and Melampsora occidentalis alternate to its needles from poplars and aspen.

As already mentioned, leaves of poplars, aspen and willows are frequently attacked by Melampsora rusts, and hawthorn and mountain ash are rusted by Gymnosporangium. Even leaves of beautiful birch are attacked by a rust, Melampsoridium betulinum.

I suggest that we not forget the native rusts of the Inland Empire since some surely have the potential to reduce forest productivity.

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SOME STEM DISEASES OF CONIFER, OTHER THAN RUSTS, DECAYS AND POLE BLIGHT WHICH OCCUR IN THE INLAND EMPIRE

Ed. F. Wicker

Preceding panel members have provided very excellent presentations on several important diseases of conifers occurring within the Inland Empire. I am certain that all of us feel more familiar with those particular tree diseases than we did a few hours ago. I should like to continue this panel discussion by presenting an abbreviated account of a few additional stem diseases of conifers which occur within the area. One of the diseases is of considerable importance because of the severity of its adverse impact on the many uses of the forests. Some of the others possess the potential to effect adverse impact and still others have not been assessed.

While the majority of forest tree diseases are caused by fungi, there are other equally important causal agents. The dwarf mistletoes, which are parasitic phanerogams, provide an excellent example. The adverse action of these pests on the forest is far less spectacular than similar action by fungi. Because of the insidious nature of their action, man has been slow to recognize the dwarf mistletoes as a forest pest of major importance and the consequences are evident.

Four taxa of dwarf mistletoes, Arceuthobium americanum, A. campylopodum f. campylopodum, A. c. f. laricis and A. douglasii,

are known to attack 12 species of conifers native to the Inland Empire and some half dozen exotics. Eight of these native conifers are among the top 10 commercial species and four are severely damaged. The damage is extensive but seldom spectacular. Trees of all ages are attacked, retarded, deformed and killed. The general nature of action by these pests is a slow suppressing effect caused by the interruption and degradation of the normal physiological processes of the tree and may be considered a form of biologically induced malnutrition.

Spread and intensification of dwarf mistletoes is extremely slow and unobsessed by time. Severely diseased stands result from persistent and continuous intensification of the pest over many years. As time passes, tree damage steadily increases and wood production decreases. In forests infected by dwarf mistletoes, the opportunity of management for maximum use is restricted or perhaps lost.

Estimates of the total annual adverse impact for the confines of the inland empire are not available. Recent estimates for that portion within the States indicate an annual adverse impact of growth reduction and mortality of over 75 million cubic feet to timber production alone. Additional losses due to reduction in lumber quality, reduction in forest potential for natural regeneration, increased fire hazard, and damage to watersheds and high value recreation areas are occurring but cannot be accurately measured at this time.

There is no panacea; no all-inclusive recipe for control of dwarf mistletoes. They can be controlled by silvicultural measures but this requires time. Such control must be based on the merits of the individual stands; we cannot prescribe general measures applicable to all stands. Practical control can best be attained through the judicious and timely application of an integrated knowledge of the biology of the pathogen, the silvical characteristics of the host, and financially sound and sanitary land management practices. Through a cooperative and coordinated effort between research and management, we can achieve the needed control. On Friday, a program proposal for such an effort will be presented by Keith Shea and Ben Howard.

The next disease situations which I wish to discuss are the stem and branch cankers of western larch, Douglas, grand and sub-alpine

firs caused by species of Phomopsis.

In 1965, I published a report on the "Carrot-top" - "Spike-Top" disease of western larch caused by Phomopsis pseudotsugae M. Wilson. The disease was first observed in northern Idaho in 1958. Diseased specimens were subsequently collected from the Kaniksu, Colville, Coeur d'Alene, St. Joe and Clearwater National Forests. I reported the symptomology of the disease and issued a warning as to its potential to inflict damage.

Current surveys in Region 1, U. S. Forest Service, indicate the disease is more widespread than first reported. It has been observed on the Kootenai, Flathead and Lolo National Forests and thus occurs essentially throughout the western larch type in the northern Rocky Mountains. The survey data indicate rather severe damage is being inflicted in some areas and that this disease in reality constitutes a threat to the management of western larch. I will say no more concerning the disease because Mr. Clint Carlson will be presenting a special report on its occurrence and I do not wish to detract from his presentation.

Stem cankers on Douglas fir caused by Phomopsis lokoyae, and flagging by branch cankers on grand fir caused by Phomopsis boycei and on sub-alpine fir caused by Phomopsis montanensis, are of common occurrence in the forests of the Inland Empire. However, these canker diseases seem to exist at enphytotic levels and only rarely is an isolated outbreak observed. They are apparently native to the area and so far have given the forest manager little reason for concern.

Stem and branch cankers on lodgepole and ponderosa pines caused by Atropellis piniphila and on western white pine caused by Atropellis pinicola are of widespread occurrence in the Inland Empire. Atropellis piniphila is the more damaging of the two because of a higher frequency of stem cankers and a high incidence in local areas of southern Alberta, northern Idaho and western Montana. Atropellis pinicola is of little significance as a canker causing fungus of western white pine. We are indeed fortunate to have an authority of this group of canker-causing fungi, Dr. John Hopkins, working within the Inland Empire area.

Dasycypha pini is widespread in the Inland Empire at elevations above 4500 feet, causing branch and occasionally stem cankers on western white pine. Girdling stem cankers and mortality have been ovserved in

seedlings but not in saplings or larger trees. Damage in general is restricted to occasional branch flagging.

RECENT DEVELOPMENTS ON RESISTANCE TO WHITE PINE BLISTER RUST

R. T. Bingham

INTRODUCTION

Somewhat shamefully, I must start by saying that it has been 14 years (Spokane, 1955) since our work on blister rust resistance in western white pine has been reviewed before this Work Conference.

To begin, I'm pleased to report that research and developmental work -- undertaken jointly by the Intermountain Station and Region One of the Forest Service--has proceeded on schedule toward the initial or "first-stage" goal, mass-production of partially resistant, interim planting stocks. This process consists of: (1) Selection of 400 phenotypically resistant, or rust-free "candidate" trees among those in heavily infected natural stands, (2) controlled crossing of each candidate with four testers and artificial inoculation of resulting F_1 progenies, (3) reselecting those parental candidates where all four progencies show well-above-average levels of F_1 seedling survival (i.e., general combining ability for seed transmission of resistance), (4) re-mating these "G.C.A." trees in pairs where both trees are representative of a "low," "medium," or "high elevation zone and producing large "GCA-F_1" progencies (usually several thousand seed), (5) artificial inoculation of GCA-F_1 progenies and selection of surviving GCA-F_1 seedlings at 4 year age, (6) outplanting the surviving F_1's in low-, mid- and high-elevation orchards (13, 20 and 7 acres, respectively), and finally, (7) production of about 9 million F_2 seed by about 1985, via natural crossing among resistant F_1's in the orchards. The F_1 averages 30% resistant (30% of the seedlings withstand intense artificial inoculation) and the F_2, due to the second increment of selection pressure exerted by artificial inoculation of F_1's in the test beds, should average near 50%± resistant under field conditions.

With the casebearer nibbling on larch to the north, and the budworm upon grand fir and Douglas fir to the south, we're going to employ this semiresistant stock in mixed-species plantings. Thus it will stretch farther than originally anticipated, and orchard acreage has been reduced accordingly, from 100 to 40 acres. Even so, we'll be planting this stock at double the desired density to retain that density after 50% rust losses.

Just how immortal is this first-stage, interim stock in the face of (probably) genetically diverse pathogen? To be perfectly honest we don't know, but are hopeful. We would also point out that within 20 years, or before 1/10 of our white pine acreage would be planted with it, we hope to come up with a much more highly resistant and rust-race-buffered type. Chances are that at least two, and possibly several more resistance-genes are involved in stage-one stocks. Once our new program of work allows us to identify these genes, hopefully we can cull stage-one orchards to eliminate the weaker "bridging types" by which the cereal rusts have so successfully leapfrogged from one resistant variety to the next.

NEW RESEARCH AND DEVELOPMENTAL WORK

From the foregoing discussion it is clear that new work has to be aimed at (1) elucidating the genetics of the host-parasite system, particularly that of the parasite, (2) increasing levels of resistance while using more efficient test methods, and (3) paying the costs of this work by improving growth rate. Several basic research, applied research and developmental work jobs are underway toward these ends.

1. Developmental Work Toward "Second-Stage" Resistant White Pine

Genetic variation required for increasing levels of resistance above the 50%± predicted for first-stage materials, and for providing insurance against new races of the rust, can be found both in western white pine and in white pines that have evolved nearer the Eurasian gene-center of the rust. For the present, wishing to avoid any cataclysmic, maladaptational problems associated with introduction of Eurasian species, or with early-generation inter-species hybrids of Eurasian species (otherwise attractive means for entering new and potentially

very important resistance genes from these species), we intend to first seek desired resistance types within the locally-adapted species of Pinus monticola.

Thus to secure the broad genetic base needed for this long-range work, Region 1 has been hard at work the past two summer seasons, expanding our base from the 400-tree, stage-one base. So far, their candidate search crews have located, examined, marked and described about 2,300 new trees; so with the stage-one trees we have about 2,700 trees of our 3,200-tree goal. Remaining search areas are mostly in the unroaded back country--there is (I hope) a "nonsense" correlation between quality of the fishing and cost-per-tree-located, in these areas.

2. Applied Research to Increase Efficiency of Selection and Progeny Testing

Recently, we completed work of testing reliability of single, mixed-polled cross progenies for estimating general combining ability of candidates (Bingham, 1967). This simple maneuver (one cross instead of four) will lower testing costs of $600 to $200 per tree. With up to 2,800 new trees to test, savings will come to over a million dollars.

Much more work, however, remains to be done in controlling uniformity of artificial inoculation, and in otherwise manipulating test designs to realize goals of testing the greatest number of candidates in the smallest possible test nursery. For instance, our present inability to control more closely variability in intensity of inoculation which occurs across replicates, in large (400-1000 running feet of nursery bed) tests, is costing us many thousands of dollars per year. Presently we are still forced to use 10 replicates, and 16 seedlings per replicate, to secure mean percentages of progeny infection having acceptable standard errors. Close control of this variable promises to reduce costs to $100 per tree, saving another half million dollars in test costs.

3. Basic Research Toward Defining the Resistance System

New and more sensitive experiments have confirmed the relatively strong genetic control of resistance and the high heritability of resistance in selected P. monticola parents (Bingham et al., In Press). This work tells us that we can expect substantial gains in resistance for each successive cycle of selection, crossing and testing. Within 20 years

we should be able to produce 70-80% resistant stocks, where higher-than-average planting density will no longer be much of a cost factor.

We are beginning to understand a bit more about the resistance system. Very recently Ray Hoff and Geral McDonald (In Press) have tentatively identified a single, non-dominant gene controlling C. ribicola needle lesion frequency in P. monticola.

However, with a tree crop like white pine, we are particularly vulnerable to introduction (or synthesis through mutation and recombination) of new and possibly virulent races of the blister rust pathogen. For this reason the bulk of our new fundamental research program, our dollars and our scientist manpower is being directed towards this problem.

Do pathogenic (not merely botanic) races of C. ribicola already exist? If so, how can the breeder combat them effectively in a long-rotation species like white pine?

Direct and indirect, if still inconclusive, evidence on the existence of physiologic races, whether botanic or pathogenic, continues to accumulate. It has been known for some time that following aeciospore inoculation with inoculum from New Hampshire P. strobus and Oregon P. monticola cankers, a different lesion type is produced on Ribes hirtellum differentials than is the case with aeciospore inoculum from P. lambertiana cankers (Anderson and French, 1955). And recently in our progeny test beds and greenhouse at Moscow, Ray Hoff and Geral McDonald have observed two different color-types of blister rust needle lesions (red and yellow) occurring on the same host plant. Also, in addition to the red and yellow types, they have classified several other fairly common needle lesion color and necrosis types. There is also indirect evidence from Europe, with Peridermium pini, as Klingstrom (1967) using three highly germinable but geographically separated sources of aeciospores, all three sources applied to different parts of the same plant, consistently obtained infection with two of the isolates, but none with the third. And in seed-source plantings of the southern pines, while there is fair consistency in performance (rust resistance) of given sources at given plantations (Wells and Wakeley, 1966), some workers suspect that divergent results at specific plantations may be the result of different rust populations there.

Now that we have enough work behind us to preserve a considerable genetic base for western white pine, and for the time being to maintain this good species among the region's timber species, we can at last attack this important problem. Here our main approach will be centered on obtaining control of rust, as well as of host genotypes. Once we refine rust cultures we will begin a systematic program for identifying any rust biotypes we may find, characterizing them by classical methods according to the infection or reaction types they induce in resistant (or susceptible) host genotypes. We know this job will not be easy because two or more pure host resistance genes may interact to produce lesion-types distinct from those produced by either host resistance- gene alone, because host genes and pathogenic races may interact with the evnironment to produce different reactions at different times, etc. For instance, we already recognize a variety of bark-reactions, in addition to the needle-lesion types mentioned above. Which of these are straight-forward single host gene-single rust race reactions, which are the product of the reactions of this simple model with a variable environment, and which are the product of much more complex interactions where a variable environment may be influencing reactions produced by a number of host and/or race factors?

Ray Hoff and Geral McDonald who have planned, and are now beginning to undertake most of this new work plan to secure genetic control of the rust first by the medium of single-aeciospore cultures, then, whether or not this constitutes sufficient control for practical testing to proceed on toward single basidiospore cultures. Obviously the first method is much more rapid, less costly and easier, but its success depends on how both meiotic and dicaryotic phenomena affect host reaction behavior. With single basidiospore cultures we will attain one more measure of control, eliminate meiotic (recombinational) effects and, incidentally, find out whether or not the rust is really heterothallic.

We are now about ready to touch off our first single-aeciospore rust epidemic in the greenhouse, using rust built up from a single aeciospore infection on a large number of rooted cuttings from a susceptible clone of Ribes petiolare. Full-sib seedlings from selected host families will now be exposed to basidiospores from this single aeciospore

culture. If differential reaction-types are then found to be associated with specific host families exposed under this level of genetic control of the rust, we will be delighted! If not, we will seek better control of the rust from other single-aeciospore cultures, or from single-basidiospore cultures.

4. Concurrent Improvement of Growth Rate

If we were to wait to get the perfect white pine on the market, I'm afraid we would still be waiting the day we heard those words--You're fired! Thus we are prepared to release first-stage materials that are far less resistant than desired, and may even be the bridges across which the rust can attack our later and better materials. It is nice to be able to say we are holding onto the flexibility the forest manager will someday need by maintaining a good species under management, but it would be better to say that the work is paying its way.

This is the reason for the other side of our white pine breeding team. Ray Steinhoff and Jerry Rehfeldt are at work at Moscow, aiming at improved growth rate for the white pine materials we select for long-range improvement of rust resistance. Heritability of growth rate is far lower than for resistance, but perhaps 5-10% per generation gains seem possible. Any small gain of this magnitude would pay the way of all resistance and growth-rate improvement work, and result in a goodly profit on the side.

DISCUSSION

The great white hope of forest tree, as well as of cereal rust resistance breeders for developing truly long-lasting resistant varieties seems to lie in maintenance of genetic heterogeniety, and in the isolation therefrom of "generalized," "field-resistance," "tolerance" or other resistance-types which neither channel racial development in the rust, nor break down in the face of exposure to a large number of rust races. Unlike the single-gene, almost immunity-imparting specific-type resistance factors--historically of such transient utility for maintaining resistance in cereals (Stakman and Christensen, 1960; Borlaug, 1965)-- these single- or multi-gene types withstand or tolerate many races of the rust and permit harvesting of a merchantable crop. Already Dr. Niederhaeuser of the Rockefeller

Foundation has identified and utilized "horizontal" resistance to potato late blight, and it is standing up all around the world. Dr. Zadoks of the Netherlands, and others, are doing similar work with wheat; Dr. Hooker of Illinois with corn, and Dr. Simmons of Iowa with oats.

With the vast heterogeniety probably available in a wild, outcrossing species like white pine, I feel that once we unravel host-parasite interactions in the rust complex, lasting success is not far away.

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CHEMOTHERAPY AND BIOLOGICAL AGENTS: UNTAPPED BLISTER RUST CONTROL POTENTIAL

Neil E. Martin

All too often man learns lessons the hard way, as evidenced in his struggle to combat devastating plant disease. History records famines resulting from epiphytotics, annihilation of plant species and shifts in agricultural endeavors, all because a seemingly insignificant microorganism remains unchecked. But because of these events, man has become more observant of conditions and agents involved in plant disease and has begun to pursue in depth the study of variables that are expressed as abnormal development as well as the study of the very basics of life.

It is interesting to note that during the late blight epiphytotic of 1845-1847 sources of resistance in Solanum demissum, a wild potato of Mexico, were available in numerous botanical gardens and that potato fields near copper refineries remained vigorous and green while those in nearby districts were reduced to a putrid mass of filth. Isn't it equally as interesting to note that 40 years before the potato blight epiphytotic, Prevost had established, through spore germination studies, the value of the copper ion as a fungitoxicant, and that six years after the potato famine de Bary demonstrated the causal agent to be a spore-producing fungus. This unfortunate timing of events is best summarized in Theodore Roosevelt's statement, "The greatest obstacle to scientific progress is the capacity of the human mind to resist the introduction of a new knowledge. This phenomenon is nothing short of marvelous." Perhaps Roosevelt was right, and yet with the tremendous advance in biochemical and biophysical technology one cannot help but feel that the pendulum has swung in the other direction and consequently nothing is protected from scrutiny.

Effective and efficient control of forest diseases encompasses the coordination of all variables related to the growth of a merchantable tree. Improving the potential of disease resistance and growth through genetics, perfecting silviculture practices, and minimizing disease effects by chemical and biological interactions are interdependent research areas,

each fortifying the other in providing a desired raw material to the wood industry. In this endeavor, chemical control, biological control, and the summation of all causes of blister rust inactivation are the areas of immediate interest to the forest disease research project of the Intermountain Station.

CHEMOTHERAPY

Plant diseases as we understand them today are at the threshold of a new era in the battle against them. The necessity of understanding the basics of life, parasitism, commensalism, saprophytism, and of biochemical and biophysical processes has stimulated rapid growth in research that will at some unknown point in time make chemotherapy of plant disease a common event.

A number of reviews involving chemotherapy with synthetic and naturally occurring compounds summarize the mechanics of control into three categories, (1) compounds that are directly toxic against the pathogen and will act to kill or inactivate it inside the plant, (2) compounds that inactivate vivotoxin and (3) compounds that increase the resistance of plants to disease (1,2,3). In order to accomplish any or all of these actions, a chemotherapeutant must not be phytotoxic or hazardous to animals but must be easily applied and absorbed and translocated to an infection site and must remain in the affected tissue for an adequate length of time. The tailoring of a compound to satisfy these requirements demands a thorough understanding of the causal agent, physiology of the disease, metabolism of the chemotherapeutant, and tolerance levels of the compound and/or its by-products in the environment.

Tissue culture is our most powerful tool in obtaining a thorough understanding of blister rust and the participating organisms. Work in tissue culture of western white pine, begun in 1965, has been successful in establishing and maintaining rust-inhabiting and rust-free tissue cultures. Fungus mycelium spreads onto the agar medium from the infected callus, but does not sustain itself in the absence of the callus. Infected callus, whether derived from telial or mycelial inoculations or directly from canker tissue, produce abundant mycelium that is being used in studies of the biochemical factors involved in

establishing infection and producing disease. Hopefully, the nutritional requirements of the fungus can be understood and satisfied to the point that mycelium can be cultured and induced to complete its life cycle in the absence of the host. To date pycniospores have been produced in culture followed by localised aecia-colored (orange-brown pigmented) areas in the mycelial mat. However, aeciospore structures have not been observed.

Current basic research coupled with an extensive screening program approach the problem of selecting a chemotherapeutant through two avenues: (1) selection of compound to do a specific job, and (2) emperically eliminating compounds that show no promise in disease control. Inability to culture the fungus separate from the host does not impede testing of chemicals for therapeutic and/or eradicant action because candidates for chemical screening will be incorporated into the agar or liquid media. Data on potential eradicant value will be compiled from callus tissue tests, rooted needle fascicles and nursery seedlings. Only those chemicals showing promise will be incorporated into field tests.

Basic research has given us some insight into the nature of blister rust disease. We are learning to manipulate the causal agent and host in a controlled culture regime allowing us to design experiments heretofore unavailable in blister rust research. As more knowledge is accumulated referent to the relation between chemical structure and chemotherapeutic activity, mechanisms by which fungicides and growth regulants permeate into living cells, and other variables that are involved in the phytotoxicity vs. fungitoxicity balance, strong advances toward solving disease problems will be made.

BIOLOGICAL INTERACTIONS

> "Big bugs have little bugs on their backs which bite them and little bugs have littler bugs, and so on to ad infinitum."--Author unknown.

And so it is in this "plant-eat-plant" world. Fungi enter into a number of mutualistic relationships with other fungi. Suffice it to say that the absorption of nutriment by some fungi from other fungal cells is

an incidental supplement to a generally saprobic mode of nutrition, for others it is a usual but not exclusive habit, while for others such mycoparasitism is obligatory. The illustration of such relationships is beyond the scope of this presentation.

A logical approach to efficient control is to capitalize on the potential of natural enemies of the blister rust fungus. Even though these agents may not be singularly effctive their role in conjunction with other controls, including chemicals, must be evaluated. In recent years indications of some degree of biological control of the rust organism have become evident in the Inland Empire.

Many fungi are known to invade or occur in association with blister rust cankers. From previous reports and from our own observations, Tuberculina maxima Rostrup appears more frequently than any of some 40 other fungi on bole cankers. The capability of this Deuteromycete to attack the aecia, and later the pycnia of the blister rust fungus was reported as early as the turn of the century. By 1930-1936 reports documented the control of white pine blister rust by the purple mold in Germany. In the meantime (1923) Cronartium ribicola had established itself in the Inland Empire. A few years later the purple mold made its presence known and the stage was set for an evaluation of its biological control effectiveness on western white pine in the United States.

Although early observations on the purple mold's ability to inactivate C. ribicola were not encouraging, the possibility that German strains, or new strains, could be more virulent than indigenous strains presents an ever present threat to the existence of blister rust cankers.

Studies in our laboratory referent to ecologic adaptability show T. maxima to invade cankers through pycnial and aecial openings in blister rust cankers. The carbohydrate content of the pycnial fluid is conducive to fungus growth while the nitrogen containing fraction has little influence. The pH optimum for growth is the predominant pH of host tissue and the range in which growth continues covers 2-3 units either side of optimum.

Current research results show T. maxima to be an effective opportunist. Now some 30 years after its known association with blister

rust, evidence is available showing the indirect manner by which reduction in aecia and pycniospore production is brought about. Research endeavors show the influence of T. maxima on canker activity to be similar in magnitude to the effectiveness of other common canker inhabitants. Consequently, T. maxima serves as an adequate model for assessing the contribution to control by biological agents.

Through studies on T. maxima, six criteria for success as a control agent have evolved: (1) distribution which coincides with that of the target pathogen, (2) ecologic adaptability sufficient to insure persistence within its host range, (3) production of abundant inoculum for establishment of epiphytotics, (4) high infectivity, (5) high virulence, and (6) an efficient mode of action for curtailing development of the target organism. T. maxima conforms to the first three criteria, but present isolates are inadequate in not having high infectivity and high virulence. Current research is directed toward elucidating the biochemical basis of its association with the target organism.

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PANEL II ROOT DISEASES AND INTENSIVE FOREST MANAGEMENT

C. H. Driver, Moderator

FOMES ANNOSUS ROOT ROT DISEASE OCCURRENCE AND CONTROL UNDER WEST SIDE CONDITIONS

G. W. Wallis

You are all aware of the damage being caused by Fomes annosus in immature stands in Europe and the spectacular rise of this disease from one of little consequence to the second most important fungus parasite in the Southeast pine plantations in little more than ten years. You are also aware that the reason for this rapid development is the ability of the spores of this fungus to infect freshly cut stumps, infection being proportional to the extent and intensity of thinning.

The primary objective of early studies with F. annosus on the west-side was to determine the potential of the disease to cause losses; the work was divided into three phases:

1) Aerial spore populations: A gross quantitative measure of seasonal occurrence of airborne spores was obtained in two areas on Vancouver Island, B. C. White pine discs served as spore traps, using the method outlined by Rishbeth and Meredith (1957).

Spores were present in the atmosphere at each sampling period but the quantity showed a marked seasonal fluctuation. The highest populations occurred in October-November, followed by a sharp fall in December with the onset of freezing temperatures. The populations increased again in February-March, declined in April and remained at low level during the dry summer months.

A correlation was not evident between spore deposition and temperature or precipitation, either prior to or at the time of trapping. When the temperature was below 45°F but above freezing for extended periods airborne spore populations increased. However, precipitation was usually high during these cool months. Spores were deposited on traps in January of both 1965 and 1966 although 30 inches of snow lay on the ground in exposed areas of the forest.

Recently, spore trapping in eastern Washington and in the interior of British Columbia has shown that there is an adequate supply of spores for stump infection in these regions.

2) Spore infection of stumps: Western hemlock, Douglas fir, western red cedar, amabilis fir, alpine fir, Sitka spruce, Engelmann spruce, yellow pine and lodgepole pine stumps have been studied for susceptibility to spore infection. With the possible exception of cedar, all proved to be highly susceptible. Of the 700 hemlock and 500 Douglas-fir stumps examined in 12 areas on the coast, an average of 21% (0-60%) and 15% (0-41%), respectively, exhibited decay which could be attributed to infection by spores at the cut surface. Of the 240 cedar stumps sampled following natural and artificial spore inoculation, only 2.5% had become infected; growth on each of the infected stumps was restricted to a small colony in the outer heartwood or in the sapwood.

Driver and Wood (1968) found that 50-90% of the thinned stumps in hemlock stands 20-60 years of age had become infected by F. annosus as a result of spore infection at the cut surface.

Growth of F. annosus in stumps of hemlock, Douglas fir, amabilis fir and Sitka spruce is rapid following spore infection; rates of 4 - 7 cm per month have been recorded in the eight months following infection, with little apparent difference in rate of penetration between host species. Some roots show advanced decay as little as two to three years following stump infection. Where stumps were grafted to living trees progress of the disease was considerably slowed; in some cases infection was still confined to the above-ground portions of the stump even though the fungus had been active for as long as five years.

Morrison and Johnson (1968) recently completed a study of stumps cut monthly over 12 consecutive months. They showed that it may not be uncommon for 100% of the stumps in some stands to become infected at certain times of the year. Hemlock, as compared to Douglas fir and amabilis fir, showed a high variability in susceptibility throughout the 12-month period, usually being considerably less susceptible than the other two species in the fall and winter months.

3) Passage of the fungus from infected roots to uninfected roots of living trees: Where stump sampling had shown that F. annosus decay was extensive, the root systems were bared to expose contacts with roots of adjacent living trees. Exposure of the root systems of 75 hemlock stumps provided us with 52 contacts between infected and living roots where we could study spread of the disease in some detail. Approximately one-half of the living roots had annosus decay present; the maximum extent of decay, seven feet from the point of contact, occurred in a stand which had been thinned 12 years prior to the study. Thirty-eight Douglas-fir stumps have also been excavated, providing us with 19 contacts between infected and living roots. Only one-third of these living roots had contacted the disease; it is important to note, however, that most of the infected living roots were in stands less than 25 years of age.

The results of the stump infection studies have convinced us that annosus root rot would, in all probability, prove to be a problem in west-side forests, and recent observations on natural infection have helped to substantiate this belief. Driver and Wood (1968) found young-growth hemlock stands in which 60% of the stems sampled were infected with F. annosus prior to felling. In British Columbia, we have found that annosus root and butt rot is much more common in young stands than we had formerly suspected. Of the butt rotted trees sampled in a 35-year-old hemlock stand, 70% had F. annosus present. In a 20-year-old Douglas-fir plantation being experimentally thinned, infection centers comprising 4 - 5 trees were not uncommon; red brown stain caused by F. annosus extended to a height of six feet in some trees. Fomes annosus sporophores were found on old stumps of mature hemlock and Douglas fir which still remained in the stand. In a 40-year-old naturally regenerated hemlock stand, only a short distance from the above noted Douglas-fir plantation, infection centers comprising as many as 15 - 20 trees were a frequent occurrence; decay was recorded to heights of 12 feet in these trees.

CONTROL

If inoculum is already present in a stand, either as a result of infected stumps of the previous stand or through spore infection of thinned stumps of the existing stand, we are faced with a problem

similar to that which has been confronting us with Poria root rot for many years and for which we still can not recommend a feasible economic control.

We have assumed that annosus root rot spread in west-side stands, as elsewhere, will be primarily through infection of cut stumps and root wounds created through thinning in intensively managed stands. Consequently it is in this area that most of the control work is being concentrated.

Chemical control: A number of chemicals have been tried elsewhere, mostly on pines, in an attempt to reduce spore infection of stumps. The most successful of these are now being tried here on the west-side.

Urea has been shown to be very effective in reducing infection of pine stumps in the Southeast. Weir, however, found no significant reduction in infection when he applied urea to hemlock and Douglas-fir stumps in British Columbia. Edmonds (1968), on the other hand, achieved good control when he applied urea to hemlock stumps in Washington. Russell and Driver are undertaking monthly tests with urea in an attempt to obtain a more accurate evaluation of this material.

Sodium nitrite, recommended by Rishbeth for control of infection of stumps in Britain, has been tested by Edmonds on young-growth hemlock and by Weir on both hemlock and Douglas fir without satisfactory results.

Borax is used widely as a stump protectant of pine in the Southeast. Results with this chemical here on the west-side, however, have been inconsistent. Edmonds (1968) and Driver, et al. (1968) found practically no surface retention or penetration of boron, and poor control of infection when borax was applied as a powder during the wet months of the year, but good penetration and control when the same material was added during the dry summer months. Weir found somewhat similar results when borax was applied to both hemlock and Douglas-fir stumps. Russell and Driver are undertaking monthly tests with both borax and sugar borax to obtain more conclusive findings.

Biological control: Rishbeth found that Peniophora gigantea and Trichoderma viride effectively reduced infection of pine stumps by F. annosus. Peniophora is now being used on an operational basis in pine plantations in Britain; spores prepared in tablet form are dissolved in water and the suspension is sprayed on stumps giving effective control.

Use of Peniophora for controlling stump infection of Sitka spruce, Norway spruce, European larch and Douglas fir in Britain has not however, been as successful as with the pines; the reason for this is probably the slow growth of Peniophora in these woods. Rishbeth (1968) has initiated studies wherein chemical solutions are added to stump surfaces along with Peniophora spores in an effort to create an environment more conducive to the rapid development of the competitor. Although he met with only partial success in his initial studies, the results, particularly with ammonium sulphate and sulphamate on Douglas fir, were sufficiently encouraging that further intensive investigations using this approach should receive high priority.

Biological control is an active part of the control program here on the west-side but little in the way of results are available at this time. Unfortunately Peniophora gigantea does not develop successfully in hemlock stumps so other competitors which will colonize these stumps to the exclusion of F. annosus must be found.

Some predictions: Fomes annosus will be a problem considerably beyond that believed by most workers in the past. Losses in hemlock in particular and probably in ponderosa pine will reach very significant proportions in the era of intensive management unless controlled. While infection in Douglas fir will not be as intensive as in hemlock, where inoculum is allowed to build up through spore infection of stumps losses will be a problem. Our knowledge of infection in other species; e.g., Sitka and Engelmann spruce, Abies spp. and lodgepole pine, is sketchy. We do know, however, that stumps of these species are susceptible to spore infection and that at least a number of these species have proven highly susceptible when planted in Europe. I would therefore suggest that losses will in fact be a problem in these hosts, and studies of F. annosus development should precede any extensive thinning operations.

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OCCURRENCE OF FOMES ANNOSUS ROOT ROT IN THE INTERMOUNTAIN REGION

A. C. Tegethoff

Prior to my transfer to Region 4 in 1965, I was Zone Pathologist for the Forest Service in the northeastern states for four years. During that time I worked quite intensively on the Fomes annosus problem. The situation in New England is considerably different from the one existent in Region 4 today.

Following the Civil War many farms were abandoned in the northeastern part of the United States. During the 1920's and 30's the CCC's made extensive plantings of red and eastern white pine on these old farms. In the late 40's and early 50's these plantations, originally planted at a 6 x 6 spacing, began to stagnate and extensive thinning programs were undertaken. A few years after the initial thinnings, mortality became evident in many of these plantations, and it was determined quickly that the root rot fungus, F. annosus, was the cause. At the time of my transfer to the Intermountain Region, virtually no thinning was being done in the northeast because of the threat of F. annosus infection.

When I arrived in Region 4, I had two reservations in mind

relative to F. annosus infection. One was that the dryness of the area would inhibit or actually prevent infection by this fungus and two, that there are few plantations on old fields in the west. I quickly lost both these reservations as I began to travel about in Region 4 and investigate disease conditions on logging and thinning areas. I have found considerable F. annosus infection in natural stands of almost all species of trees in this Region.

I have now been in the Intermountain Region for a little over three years and while I work on many problems, each time I go into the field I am alert to locating areas of F. annosus infection. To date I have found F. annosus killing ponderosa pine, Jeffrey pine, lodgepole pine, pinyon pine, subalpine and white fir, and western juniper. I have isolated it from a heart rot of living Engelmann spruce and also from mountain mahogany. I have found fruiting bodies on the evergreen shrub (mountain lover) genus Pachistima. Its occurrence on Douglas fir in the Intermountain Region is unknown to me. I have found it on eight National Forests of the 18 in Region 4. This slide will show you the distribution of F. annosus as I know it as of today. On the occasions when I have been able to dictate the conditions under which I would like to look for the disease, I have had no difficulty in finding it. By this I mean that I would ask a District Ranger or Timber Staff Officer to direct me to an area that had been logged or thinned 10 to 15 years ago. When these conditions were met, particularly in the pines, or subalpine or white fir, I had little difficulty in discovering annosus infection. From empirical observations made in New England, the average rate of spread was approximately one foot a year. I have roughly determined that in Region 4 the rate of spread is one and one-half feet a year. These figures were arrived at by measuring the distance from the originally invaded stump to the most recently killed tree and dividing that distance by the years which have elapsed since that stump was created. Of considerable interest to me is the apparent faster rate of spread in the more arid west as compared to the one foot per year rate of spread in the moist northeastern states. Are there few antagonistic organisms present in drier soils? On muck soils in the northeast there was virtually no spread of F. annosus infection, even though I have seen stumps literally ringed with conks. These muck soils have a very high organic matter content

and I assume they are ideal environments for many antagonistic organisms.

In New England, it was quite uncommon to find F. annosus infection in a natural stand growing in a natural forest soil. In Vermont, I did find F. annosus infection in an area of natural red and white pine. This area had been logged twice in the past and a certain level of mortality was occurring. However, spread of the fungus and consequent losses were not nearly as great as those occurring in infected plantations. One common factor which I observed both in New England and Region 4 is that F. annosus seems very dependent upon moisture for fruiting. The recently ended drought in New England made it very difficult to find fruiting bodies of annosus except where moisture was available from sources other than precipitation. This same dry condition always exists in Region 4. I have found considerable fruiting of this fungus inside of stumps, but again conditions must be moist. If the stump is dry when I chop into it, I can almost always correctly predict that fruiting bodies will not be found. My first experience of finding conks in stumps was on the Toiyabe National Forest in western Nevada (eastside Sierras). This area had been logged in the late 30's and considerable mortality was occurring on the flat and on the hillside above it. I was unable to find conks at the base of the dead trees. I then remembered something that Fields Cobb had told me about finding conks inside of large stumps. I chopped open the one nearest to me and immediately found a conk as large as my hard hat. Since then, I have always been alert to finding fruiting bodies in stumps when I could find them nowhere else. I would like to present another example of the relation of moisture to fruiting. An area of dead and dying subalpine fir was noted on a campground on the Wasatch National Forest. Considerable wind-throw had occurred and it was assumed that some sort of insect outbreak had occurred. However, when our entomologists examined the area, no signs of insect activity could be found. I was then asked to examine it for possible diseases and found extensive fruiting of F. annosus on the roots and in the chambers created by the root masses of the wind-thrown trees. This site was naturally moist, had a northern exposure and, consequently, the fungus fruited quite readily. Last month while on the Targhee National Forest I was asked to look at an area of dead and dying lodgepole pine, and while all the symptoms appeared to be caused by F. annosus infection, I wanted a fruiting

body for positive identification. I finally had to almost crawl into the root cavity created by a wind-thrown tree before I was able to find any fruiting bodies and those I did find were very small. The difference between these last two cases, other than the different tree species involved, was that on the Wasatch National Forest the soil was naturally moist, while on the Targhee the soil was sandy with under-lying factured lava. Water retention in this condition was very poor; consequently, it was quite difficult to find conks of F. annosus. Spread of the fungus through the root system does not seem to be inhibited by dryness either in the northeast or in Region 4.

While we are all familiar with the relative ease with which this problem can be controlled (actually prevented, but I will use the term "control"), a program such as would be required to control the fungus over an area like Region 4 is a very complex and costly undertaking.

Before we could even think of instituting a control program, our losses to this fungus would have to become severe enough to justify such a program.

At the present time, at least as far as I know, we are not suffering losses of this magnitude. While I just stated that this would undoubtedly be an expensive program, the actual material costs, including shipping, are quite low. (Based on Charlie Driver's figure of one pound of borax to 50 square feet of basal area of stump, the cost of the amount of borax to treat a 30-inch diameter stump would be one cent. However, this cost does not include labor required to transport material to the logging job and transporting it from tree to tree, nor does it include costs of application.) The program expense becomes evident when one considers all the stumps that would have to be treated throughout Region 4 every year.

Control of this fungus on thinning areas is even more of a problem. I have been assured by our Branch Chief in charge of Silviculture, that were we to treat stumps created by thinning, thinning costs would increase by one-third to one-half, due to the large numbers of small stumps per acre. I cannot vouch for the accuracy of this figure, but I agree with him that stump surface treatment on thinning areas will

add considerably to costs. Because of this, I have been planning with the Pacific Southwest Forest and Range Experiment Station to test the effectiveness of cutting high stumps as a possible control measure.' However, even though this may prove effective, I anticipate considerable resistance from Forest Supervisors to the practice of high stumping in thinning areas.

A few months ago, Chuck Hodges mentioned that his group was doing research on biological control of F. annosus. The method being studied is to increase the quantity of antagonistic organisms in an area in which cultural work is to be done. Hopefully this will be accomplished by seeding the area some time prior to the cultural work with the antagonistic microorganisms. This is a form of biological control that appeals to all of us, but it also presents a number of problems. The native organisms antagonistic to F. annosus in the Region 4 area would first have to be isolated and a method of growing and inoculating an area with them developed. Reliable personnel on each of 120 Ranger Districts would have to be trained in the proper techniques required to seed an area with these organisms prior to any kind of cultural work. In order for this to be effective, all timber sales, thinning areas, road and campground construction, etc., would have to be seeded months before the actual work began. However, anyone familiar with Ranger District activities can appreciate the problems involved. This is an interesting approach to control of F. annosus and is the one being followed by John Rishbeth in Great Britain. Finally, in closing I can only state that I expect to find much more F. annosus infection in the future in Region 4, but cannot predict at this time whether our losses will reach that order of magnitude which will require control.

PORIA ROOT ROT

PORIA WEIRII--IS THERE HOPE FOR CONTROL?

Earl E. Nelson

Poria weirii (Murr.) was first described in 1914 causing a root and butt rot of western red cedar in Idaho, and was first reported in 1929 on Douglas fir on Vancouver Island. Western forest pathologists

have been concerned with this pathogen in valuable Douglas-fir forests for nearly 40 years and during this period have learned much of interest and of potential value about it.

Poria weirii attacks virtually all native conifers although some, such as western red cedar, appear to be more resistant than others. The fungus grows ectotrophically over roots, passing from roots of infected trees to those of healthy trees when contact or near-contact is made. Since underlying root tissue is penetrated from this relatively fast surface mycelium, spread of infection is hastened. Growth of the fungus over inoculated roots under otherwise natural conditions has been measured at about 20 cm during the first year but much faster growth might be expected after the fungus has become better established.

Roots of Douglas-fir stumps can be colonized by P. weirii 12 or more months after cutting depending, probably more than anything else, on the initial invaders of the root wood.

The fungus can survive in small roots for more than 10 years and in stumps and larger root systems for more than 50 years. The survival of individual mycelial masses depends upon many circumstances, not the least of which is microbiological activity.

From wood in an advanced stage of decay, P. weirii produces inconspicuous sporophores with abundant basidiospores in late summer or early fall. Although the importance of basidiospores in spread of the disease is questionable, some new infection centers undoubtedly result each year from spore infection. Natural infection of stumps by spores is yet to be demonstrated, and attempts to artificially inoculate stumps with spores have not succeeded.

Effective methods for inoculation using P. weirii mycelia have been devised for roots in Victoria and for stumps in Corvallis.

Bits of information on the physiology of P. weirii are known but much more is needed. Most certainly there is a continued need for basic research on this root disease, but at the same time we must attempt to apply our knowledge, no matter how meager, toward development of practical control measures.

Economic gains from control measures can be assessed only by comparing effectiveness of control and its costs to long-term losses in productivity in the absence of control. Costs and effectiveness can be determined only through experimentation, while long-term losses can only be roughly estimated.

Unless spore infections prove to be important, control need only reduce root infection by minimizing contact of inocula with roots of susceptible trees. This may be achieved by reducing frequency or longevity of inocula, or by reducing frequency of root contact between susceptible trees.

The Forest Research Laboratory in Victoria and the University of Washington have begun studying effects of stump removal by heavy equipment on development of P. weirii in succeeding stands. Even if inocula left in the soil is short-lived (which is yet to be determined), Canadian cost figures indicate that this treatment presently is economically feasible only on the best sites.

Other means of reducing residual inocula, either chemical or biological, are for the present unlikely but by no means beyond future possibility. We know that competitive microbes are important in reducing survival of P. weirii but we must still determine the measures necessary to encourage their actions. Possible effects of fertilization or of post-harvest site treatments on biological activity in soil might reduce longevity of P. weirii inocula.

Direct chemical treatment of infected trees and surrounding soil has been attempted at the Victoria laboratory. Phytoactin, actidione, Chemagro 2635, Dexon, ammonium sulfamate and sodium arsinate applied to both naturally infected and inoculated trees and to the soil as a drench, resulted in no apparent loss of vigor of P. weirii after 3 to 9 months.

Until means are devised to reduce longevity of buried inocula, control methods designed to reduce spread of the disease by decreasing root contact of susceptible hosts seem to be our best bet.

The answer to most of our P. weirii problems might be development of resistance in Douglas fir. Unfortunately, no great degree of resistance has yet been found in this species. No search with this

specific purpose in mind has been organized, but field observations have not been encouraging.

The Victoria Laboratory, in cooperation with the Vancouver Forest Products Laboratory, is testing effects of root constituents of healthy and diseased Douglas-fir trees on development of P. weirii in vitro. Thus far, reported differences in phenolic constituents between healthy and diseased roots offer some hope that resistance mechanisms may be operating within the species. The most obvious differences are the absence of dihydroquercetin-3'-glucoside in root sections with advanced decay, and the occurrence of an unknown chemical only in healthy roots. The association of another unknown with decay suggests that this compound may be a phytoalexin.

Control of a disease by use of resistant lines is perhaps the most desirable method, but breeding programs take time even if highly resistant individuals can be found. Meanwhile, damage might be reduced by silvicultural practices. Reducing root contacts by initial wide spacing or thinning of susceptible conifers might resist spread of the disease if the proper spacing were maintained. Besides silvicultural disadvantages, natural regeneration makes controlled spacing difficult, and 15 years' records indicate that thinning does little to reduce damage in stands already infected when thinning begins.

Interplanting resistant species of lesser commercial value, such as red alder or other native hardwoods, probably would best maintain a system for minimizing root contact between susceptible species while fully utilizing growing space. Plans have been made at the Victoria Laboratory to study rate of infection and spread of P. weirii in cutover infection centers planted to mixed conifers and hardwoods as compared to pure conifers. Spread in mixed stands planted on cleared land will also be studied.

Red alder might be an exceptionally promising candidate for interplanting. In addition to its merchantability in parts of the west, this species enriches soil through symbiotic fixation of nitrogen in root nodules. The presence of large amounts of nitrate in alder soil may also reduce spread of infection and survival of P. weirii which, like many basidiomycetes, cannot utilize this form of nitrogen.

Some of the inhibitory phenolic compounds produced by red alder may find their way into the soil from litter and roots to affect this pathogen. The fungitoxicity of phenolic compounds, especially those in alder, is being tested at the Corvallis Forestry Sciences Laboratory. Field survival tests of P. weirii in 2-inch wood cubes indicate that the presence of alder in a stand near the Oregon coast reduces survival of P. weirii. Although data are scanty, the fungus survived best under pure conifers, next best under a mixture of alders and conifers, and least under pure alder. We are continuing our investigations with a paired-plot study to better measure the effect of alder on survival.

Control of P. weirii by interplanting alder or other hardwoods is promising but may raise new silvicultural questions that will need to be answered.

Interplanting resistant conifers probably would create fewer management problems, but what species would be suitable? At the University of Washington's Pack Forest, rust-resistant white pine will be planted with Douglas fir on a cut and burned-over site previously occupied by a diseased stand. This site is well suited for white pine but whether or not the pine proves more resistant to P. weirii remains to be seen. Until resistance of coniferous species is well established, only the species best suited for a particular site need be considered.

Perhaps we should take a closer look at resistance of native conifers to P. weirii. Although all native coniferous species have been reported susceptible to P. weirii, the degree of resistance has been poorly defined. At Corvallis we have what we hope is an acceptable technique for inoculation of potted seedlings, and in mid-November we plan to test the resistance of 10 native conifers to P. weirii infection. In addition, it is hoped that insight can be gained on possible resistance mechanisms which might be involved. This study will be an initial step to determine possible resistance, but other studies under more natural conditions will also be needed.

Certainly, we have only begun to test potential control measures against this disease, some of which may prove highly successful and others worthless. Until we find out more about the physiology of P. weirii, its interactions with host roots, and the environmental factors that control

its establishment and spread, we can only grope for successful control measures.

There is hope for control of P. weirii, hope that rises with each new bit of information we uncover concerning this pathogen. But we will not control it tomorrow. Perhpas the time is near; we can only guess. But it is coming.

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RHIZINA ROOT ROT

RHIZINA ROOT ROT: ITS INITIATION, DAMAGE AND CONTROL

J. H. Ginns

This disease, Rhizina root rot, is not new; rather it is becoming more prevalent. This interpretation is based on discussions with foresters and on the increased use of fire as a silvicultural tool. The acreage of prescribe burn in British Columbia has doubled from the 12,500 acres slash burned in 1952.

The inconspicuous nature of the fungus is evident from discussions with foresters. Even if recognized as a fungus, it is not readily associated with seedling mortality. Rhizina has apparently, contributed to seedling mortality in the past.

Weir in 1915 reported that Rhizina often occurred on fire sites in the northwest but usually as a saprophyte. Only two other reports were found implicating Rhizina in the death of a few pines (Davidson 1945; Zeller 1935).

The association of apothecia with dead and dying Douglas-fir seedlings was observed in British Columbia last fall. This past year an extensive survey has shown the fungus to be widespread in coastal British Columbia, and present but more scattered in the interior wet zone. Its wide distribution is not surprising as herbaria specimens indicated

a distribution from Nova Scotia to South Carolina, from Alabama to California and north to the Northwest territories. In addition, it is widespread in central and northern Europe and occurs in Japan.

Sporophores and cultures obtained therefrom agree with those from Europe, thus we have the same species that is causing concern in Sweden and England.

Apothecia can be found from May to November but are most abundant in late summer and fall. Although frozen for short periods, they will release spores after thawing. Apothecia are confined to burned areas and arise on duff and mineral soil, frequently under slightly raised logs, branches, roots and stumps. We have found them to be most prevalent on hemlock-balsam areas.

Microscopically the fungus is readily distinguished by its ellipsoidal ascospores and yellow setae, which protrude through the hymenium. In culture its growth rate is very rapid, being 10-15 mm per day. Rhizina discolors tannic acid agar but not gallic acid, indicating the presence of a more specific polyphenol oxidase system than found in wood rot fungi. It has been shown to produce cellulolytic and pectinolytic enzymes but their efficiency has not been expressed in terms of its capacity to decay wood. In fact observations indicate that Rhizina does not attack sound wood.

The apothecia, as mentioned earlier, are produced from May to November, thus ascospores are being released for nearly 6 months of the year. Apothecia appear a minimum of 15 weeks after the fire. However, they are not found on fire sites on neutral or alkaline soils, but on acid sites are most prevalent around fresh conifer stumps. There is a good correlation between killing of seedlings and numbers of apothecia on an area. The role of spores in disease development seems well understood. Ascospores are airborne and as such they are rapidly diluted as distance from the source increases. The substrate upon which an individual spore lands is determined arbitrarily. Of those spores landing on burned or unburned soil or duff only 1-5% germinate and seedlings planted on these areas do not become infected. However, 40-50% germination can be obtained after heat treating the spores. Temperatures in the 35-55^{o}C range stimulate spore germination. The relationship of Rhizina to burnt areas and woody debris was demonstrated by a series

of treatments applied to small plots (Jalalludin 1967). First soil was removed, roots left intact, the area was covered with soil free of ascospores and burned, subsequently no Rhizina appeared; in treatment 2, ascospores were added after burning, again no Rhizina appeared; however, when ascospores were added at various points on the plot prior to burning, apothecia were produced but only near the margins of the burn area; treatments 4, 5 and 6 were like 1, 2 and 3 except all roots were removed from the plots; no Rhizina appeared. Thus apothecia were formed only at the margins of fire sites which contained intact roots and which had been inoculated prior to burning.

Temperatures which stimulate spore germination in the lab. (37-55°C) occur in a zone at the margin of fires and also underneath them. Temperatures outside this zone probably are not sufficient to stimulate germination and those inside it are no doubt lethal.

After spore germination Rhizina first colonizes stump roots or well-decayed woody debris in the soil. Saprophytic survival is approximately 2 years as seedlings planted at that time were not infected.

Much of the surface root system of trees and freshly cut stumps which lie under fire sites are killed by heat, while temperatures near the zone of spore stimulation seem to cause root exudations. In the laboratory, extracts from heated roots or soil were stimulatory to spore germination. Autoclaved roots did not promote mycelial growth.

Typical of Rhizina are the yellowish fibris of mycelium which develop beneath apothecia. These ramify in the duff and soil, and can be traced from the fruit bodies down to the surface of roots.

Roots of all diameters, varying from fine feeding roots to the main roots next to the stem, are attacked. Successful isolations can be made in the early stages of seedling infection, but in later stages it is more difficult owing to the presence of secondary invaders.

Rhizina apparently enters through lenticels (Murray 1961). The white spots seen on the surface of roots are resin-filled attacked lenticels. In some cases the resin effectively bars entrance of the fungus. In other cases invasion is halted by the formation of a cork cambium.

On removal of bark scales the infection spot shows with a definite dark boundary delimiting diseased from healthy tissue. If the cork cambium is not successfully laid down, the infected area shades into light brown or yellow at the margins, where the infection is extending.

Mortality of seedlings planted on an infested site begins as early as 4 months after planting. Mortality varies from slight (up to 25%) to very heavy (70-100%). Maximum mortality occurs in the first season after planting and usually ceases after the second year. In Sweden, Rhizina is the largest problem connected with securing satisfactory regeneration on burnt areas. In one year 50% of the burns became infected; 12% of which incurred greater than 50% loss that first year. At Powell River, British Columbia, an area burned and planted in 1965, had only 20% seedling survival in 1966. The site was replanted in the spring of 1967 and Rhizina was fruiting abundantly by late fall. Seedling survival only 7 months after replanting was 20%.

The actual dollar value of seedling loss is difficult to estimate. The replanting costs are direct losses. Indirect losses occur where Rhizina causes slight seedling mortality; it is uneconomical to replant these areas but the value of timber production lost as a result of seedlings killed contributes to the total loss caused by Rhizina.

On infested sites two major factors affect the degree of seedling mortality. The first is the length of time since the area was cut. Rhizina appears in greatest numbers the year after burning, thereafter diminishing. Burning is done as soon after cutting as possible, as is planting. Thus seedlings are exposed to the fungus when it is most abundant. The postponing of burning would reduce the susceptibility of stump roots to colonization but it would also greatly increase the fire hazard - the prime reason for slash burns. By postponing planting a year or two there would be much less chance of losses from Rhizina, but in many areas the growth of weed species would overtop the seedlings and make planting more difficult.

The second factor influencing seedling mortality is the species composition of the former stand. In Sweden, apothecia are most common around pine stumps and mortality was 7% greater in pine versus pine-

spruce areas. In British Columbia, fruiting is common around hemlock and balsam stumps but non-existent near red cedar. Several attempts at controlling Rhizina have been made and others suggested. Fungicide treatment of seedlings is ineffective but systematic fungicides have not been tested.

Indirect control suggestions are:

A) avoid burning, but the problem of trying to regenerate after logging is ten times greater than Rhizina;

B) light burns, but slash remains as does humus cover;

C) postpone burning;

D) burn then postpone planting;

E) chop slash.

SUMMARY

Rhizina is widespread in coastal and wet interior zones. The condition favorable for disease development (acid soils, heavy growth of bracken fern and high rainfall) exist throughout coastal British Columbia, thus it is expected that the occurrence of, and damage by Rhizina will increase, particularly as the practice of burning slash on adjacent areas in consecutive years increases. This is the first time in North America that Rhizina has been reported as A) associated with significant tree mortality; B) pathogenic on Douglas fir; C) occurring on areas purposely broadcast-burned to prepare the site for planting, and D) associated with mortality of field planted seedlings.

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PANEL III FACTORS GOVERNING THE DISTRIBUTION OF DWARF MISTLETOES

Richard B. Smith, Moderator

SOME ECOLOGICAL CONSIDERATIONS OF DWARF MISTLETOE IN CANADA

John G. Laut

Dwarf mistletoes--Arceuthobium americanum on jack pine and A. pusillum on black and white spruces--are present in roughly 1/4 of the approximately 400,000 square miles of forests and almost all the presently accessible commerical forest areas of Manitoba and Saskatchewan. As in most other dwarf mistletoe situations, within the illustrated general range the parasites actually have a "patchy"-distribution at 3 organizational levels: i.e., there are relatively large areas where they are evidently unable to become established. Within a given geographic area that is infested there are stands or sites from which the parasites are excluded, and finally within an infested stand there commonly are found individuals and groups of trees that remain uninfected.

There are three possible explanations for the apparent natural exclusion of dwarf mistletoes:

1. Happenstance: i.e., the exclusion is merely an expression of time and the inherent slow rate of spread of the organisms, and/or disturbances, such as fire, that have eliminated the parasites.
2. Genetic barrier: i.e., the local population of host species are immune or resistant to dwarf mistletoe invasion (e.g. Roth, 1967).
3. Unfavorable environment: i.e., the exclusion is real and is the result of some environmental factor or combination of factors that allow the host to thrive but prohibits the establishment of dwarf mistletoes.

Since, in searching for effective control methods, it would appear that we should emulate Mother Nature's methods of eradication and exclusion, we have recently established a project aimed at exploring certain aspects of these possibilities.

The first question that arises is whether the exclusion is real in biological terms, or only an artifact of time and/or observation technique. Certainly this latter is responsible for certain observations made in the past and probably even now. However, I would like to present some ideas and some data that suggest that exclusion is real.

Let us first examine the distribution of A. pusillum, since it may not be too familiar to many of the members of this conference. Even though A. pusillum has been known in Eastern Canada since 1902 (Churchill, 1902), there are notable gaps in its distribution. In spite of various published reports of its presence "throughout the range' of its hosts in various parts of Canada (e.g. Sippell, Rose and Larson, 1968), when all available published records were examined it was evident that vast areas of spruce forests are not represented in dwarf mistletoe collections. In fact, east of Manitoba there is evidently no dwarf mistletoe north of 50^{o} N latitude and below this latitude there are many large gaps in the distribution. The northern extreme of A. pusillum is in Manitoba--ca. $54^{o}30'$ N lat. and the western extreme is in Saskatchewan--ca. 103^{o} W long. In both cases the host trees, black and white spruces, extend far beyond these extremes.

The most likely explanation for the northern limit is climate. The reason that A. pusillum is not found further west is not as evident. We have noticed many large gaps in the distribution record particularly south-central Ontario, southern Quebec and in the Maritimes.

In an effort to find some meaningful interpretation for these gaps, all known collections were spotted on the Forest Classification of Canada map (Rowe, 1959). Many of the gaps were found to coincide with certain of the forest sections as delineated by Rowe.

Starting from the west, the western limit of A. pusillum coincides with the boundary between Rowe's B15 (Manitoba lowlands) and B18a (Mixedwood section of the Boreal Region). A. pusillum has never

been recorded west of the B15 section. Further east, spruce mistletoe is absent from sections[1/] B14, Lower English River Section; B21, Nelson River Section; B22a, Northern Coniferous; B8, Central Plateau Section; B7, Missinaibi-Cabonga Section; B3, Govin Section; L4c, Middle Ottawa Section; L3, Middle St. Lawrence Section; L4D, Georgian Bay Section; L8, Haileyburg Clay; B1a, Laurentide-Onatchiway Section; B2, Gaspe Section; A1, New Brunswick Uplands Section; A2, Upper Miramichi-Tobique Section; A10, Southern Uplands Section; A6, Cape Breton Plateau Section; B30, Avalon Section; B31, Newfoundland-Labrador Barrens Section, and B28c, Anticosti Section.

One anomaly in this analysis is worth special note. The Sprucewoods area in southern Manitoba is considered by Rowe to be equivalent to the 18a section. This area forms an outlier and is separated from the main Mixedwood area by many miles of parkland and grassland. As noted above, A. pusillum does not appear in this section, but in the outlier it is very common on white spruce and in fact threatens to eliminate that tree from the Sprucewoods.

The known distribution of A. americanum has been examined in a similar fashion. In our area it is found on jack pine, further west it is found on lodgepole and where the two species overlap, the hybrid is also attacked. The northern limit of A. americanum is slightly north of 59° N latitude and the eastern limit is 96°30' -- near the southern end of Lake Winnipeg in Manitoba (Laut, 1967). As with A. pusillum, certain gaps in the distribution of A. americanum are obvious when they are mapped. Examination of these gaps in light of Rowe's classification shows that here too they coincide with certain of his delineated Forest Sections. From the east, which is limited by Sections B14, B21 and L12, the first gap is seen to be the south-east "leg" of the Mixedwood Section (B18a) although A. americanum is common through all the remainder of this Section. This "leg" contains the so-called Manitoba Highlands, a series of elevated areas (max. elevation 2,727') from which dwarf mistletoe is excluded.

1/ The following lists of Forest Sections do not include those from which dwarf mistletoes would be expected to be excluded by reasons of isolation from the range (e.g. too far north) or lack of suscept tree species.

In Alberta A. americanum is excluded from Sections B19a, Lower Foothills Section and B19c, Upper Foothills Section. Again an anomaly, parallel to that mentioned in regards to A. pusillum, should be pointed out. The Upper Foothills Section (B19a) has a notable outlier separated from any forest area by several hundred miles -- the Cypress Hills of south-eastern Alberta and neighboring Saskatchewan. A. americanum, although absent from other B19a areas, is present in this outlier in the Alberta portion of the Cypress Hills.

Further west, in British Columbia, A. americanum is absent from the Columbia Forest Region, sections CL.1 and C1.2, and the Coastal Forests; and is found only in sections of the Sub-alpine and Montane Regions.

The reasons for the exclusion of dwarf mistletoe from certain definable ecologic areas are presently unknown. We have some ideas, with supporting data, which will be presented in later communications. For present purposes it is sufficient to point out that, since the gaps in their distribution coincide with independently conceived ecological boundaries at such a large scale, this provides strong evidence that neither happenstance or chance, time, nor disturbances can account for the exclusion of dwarf mistletoes and that such exclusion is real and is based on biological factors.

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ECOLOGICAL ASPECTS OF DWARF MISTLETOE DISTRIBUTION

Frank G. Hawksworth

Although we are at the state where the distribution of the various Western dwarf mistletoes is fairly well known, the underlying factors affecting mistletoe distribution are far from understood. From the ecological standpoint, it is frequently as important to know where dwarf mistletoes are not found as where they are.

I plan to discuss some factors that seem to play a role in dwarf mistletoe distribution, with particular emphasis on the species present in the Central Rocky Mountains and in the Southwest. I'll discuss them under these major topics: stand history, climatic effects, site factors and tree factors.

STAND HISTORY

In discussing stand history, we usually consider the past one or possibly two forest generations. However, for this presentation I'd like to go back further and discuss the geological history as it relates to paleogeography of the dwarf mistletoes.

As many of you know, the present center of Arceuthobium distribution is in Mexico and some have thought that this was perhaps the center of origin of the genus. However, I think that the available evidence strongly indicates that this is not the case and a Northeast Asian origin is more likely. The fossil record of Arceuthobium is meagre but there are reports of dwarf mistletoe pollen from Alaska in the early Miocene (ca. 20 to 25 million years ago) and from Colorado in the mid-Miocene (ca. 15 to 20 million years ago). Thus, these parasites were well established in northern North America before the pines began their rapid evolvement in Mexico. Other evidence that the genus originated in the Old World is that dwarf mistletoe pollen records there date to the Eocene (ca. 50 million years ago) and that this is the center of origin of the coniferous hosts of the dwarf mistletoes (Pinus, Picea, Tsuga, Pseudotsuga and Larix). Also, Arceuthobium is the only genus in the mistletoe family that occurs in both the Old and New Worlds. Another bit of evidence

for an Asian origin is the occurrence in Southeast Asia of a closely related genus Korthalsella. These plants are leafless, chromosomally very similar to Arceuthobium, and one species even occurs on conifers (Podocarpus) and has explosive fruits.

As new hosts evolved in North America, the dwarf mistletoes found a happy hunting ground and evolved many new forms. Of the approximately 30 dwarf mistletoes now known, all but 4 are North American.

Since the dwarf mistletoes have been present for so long in North America, most of them, I suspect, have become established in most areas that are climatically suited to their development. However, Ed Wicker will discuss some apparent exceptions to this in regard to the establishment of Douglas-fir dwarf mistletoe west of the Cascades. In general, if we map the distribution of each mistletoe and its principal host or hosts, we find that the mistletoe is centrally distributed within the range of the host. In no case that I can think of (except for those mistletoes that occur at sea level) does the parasite reach the limits of the host. As with most generalities dealing with the dwarf mistletoes, there are some exceptions to this "centrally distributed" rule. A. americanum is centrally distributed within the range of lodgepole pine but it occurs only in the western part of the range of jack pine. John Laut will have a lot more to say on this subject. Other exceptions are the two spruce mistletoes, A. pusillum in the East and A. campylopodum f. microcarpum in the West, both of which occur only in the southern parts of their hosts' ranges. Here, I suspect that glaciation in the northern spruce ranges has played a major role in the present limited distribution of these two parasites.

In the Southwest and Mexico, at least, the evidence is quite strong that the present distribution of Arceuthobium represents remnants of populations that were once more continuous. In New Mexico, for example, a few thousand years ago the vegetation zones were as much as 3,000 to 4,000 feet lower than they are today (Antevs 1954). As the climate gradually became drier, the zones retreated upward and several stands that were once continuous became isolated on the higher points. Today some ponderosa pine stands are separated from other stands of the type by 50 miles or more. Still such stands, even this isolated, have

ponderosa pine dwarf mistletoe and it is difficult to consider that the parasite arrived there by any cross-country means of spread.

Thus, I feel that the association of a dwarf mistletoe with its particular host species has been a long and intimate one developed over eons of time.

But to return to the more conventional aspects of "stand history", we all realize that fire has been of primary importance in mistletoe ecology. Fire both encourages and discourages dwarf mistletoe depending on whether we look at the long or short view. In infested stands, fire tends to keep the parasite in check because usually spread of the parasite into burned-over stands is slower than the return of the host trees. In a broader sense, fire favors the spread of dwarf mistletoes in that it tends to keep forest succession in the more susceptible seral state than in the usually more mistletoe-proof climax stage.

Cutting can have much the same effect as fire in that it can favor or discourage dwarf mistletoes depending on how it is carried out. Other factors that limit dwarf mistletoes are natural catastrophies such as volcanic activity (Hawksworth 1960).

CLIMATE

A broad aspect of mistletoe ecology that has not been investigated is the effects of climatic factors on their distribution. For example, I suspect that this is an important, if not the primary factor, limiting the northern distribution of A. vaginatum subsp. cryptopodum on ponderosa pine and the northeastern limits of A. douglasii on Douglas fir. Arceuthobium vaginatum is a fall-germinating species and the cooler September-October temperatures that it encounters as it attempts to move northward may be lethal to the germinating seeds. Arceuthobium douglasii is a spring-germinating species so other aspects of climate must be involved in its limits. In any case its absence from the parts of the range of Douglas fir with the most severe climate (central British Columbia, Montana, Wyoming and northern Colorado east of the Continental Divide) suggest some type of climatic limit. Probably climatic factors also limit the northern distribution of Arceuthobium americanum.

SITE FACTORS

Site factors also influence the distribution of the dwarf mistletoes, but we don't know just how. For example, topographic position, aspect, steepness of slopes, soils, site quality and elevation all affect mistletoe distribution to a greater or lesser extent. I feel that these factors have a fairly strong influence because, in spite of the masking effect of fire and cutting history, they are still apparent in most stands.

Topographic Position: Our surveys in ponderosa pine and lodgepole pine (Hawksworth 1958, 1959) confirm the common observation that these mistletoes are most frequent on ridge tops and relatively rare in bottoms. However, our surveys also showed that ridge sites constitute only a small (less than 5%) proportion of the forest stands and that most infested acreage is on side hills.

Steepness of Slopes: Our studies in the Southwest and Colorado show that for some yet unexplained reason, ponderosa pine dwarf mistletoe is strongly associated with steepness of slopes as shown below; the steeper the slope, the less infection:

Steepness of Slopes	Percent of Plots with mistletoe	
	Mescalero New Mexico (Hawksworth 1959)	Manitou, Colorado (Hawksworth 1968b)
Gentle (less than 5%)	57	87
Moderate (5 to 30%)	53	51
Steep (Over 30%)	45	34

We haven't yet determined whether or not there is any such relationship for the other Rocky Mountain dwarf mistletoes.

It is of interest that Lew Roth (1954) reported an opposite relation for A. campylopodum in ponderosa pine at Pringle Falls, Oregon. There he found much more infection on steep slopes than on gentle ones.

Aspect: Aspect has some influence on mistletoe distribution, and in our studies on the Mescalero Reservation in New Mexico we found that ponderosa pine mistletoe was most common on west and southwest exposures

and least common on north and northeast slopes (Hawksworth 1959).

Soils: Although there have been a number of observations on the effects of soils on dwarf mistletoe distribution (e.g., Korstian 1924), little quantitative date on this subject are available. In the one study that we conducted, we didn't find a relationship between soil type and ponderosa pine dwarf mistletoe in one area in Colorado (Hawksworth 1968b). With the increasing amounts of soils data now available for many forest areas, we should be more alert to the possibility of using this information to determine the relationships of soils and dwarf mistletoe distribution.

Site Quality: The question of the relationship of dwarf mistletoe abundance and site quality has long been a subject of debate, probably because there is no simple relationship; i.e., some mistletoes are most abundant on the better sites, some on the poorest and some seem to show no relation to site.

In the Southwest, ponderosa pine dwarf mistletoe is common on ridge sites, but this doesn't necessarily mean that it favors poor sites because other poor sites (e.g. at the lower margins of the ponderosa pine) have little or no mistletoe. Actually, the evidence to date shows that this dwarf mistletoe, on the average, is more abundant on the better sites (Andrews and Daniels 1960).

In our studies of lodgepole pine dwarf mistletoe, we have been hampered, until recently, by the lack of a suitable method for evaluating site index. We now have studies in progress that should enable us to evaluate the effects of site quality on impact of lodgepole pine dwarf mistletoe.

Daubenmire (1961) reported that Arceuthobium campylopodum in the Inland Empire was confined to the 2 poorest of the 7 ponderosa pine habitat types recognized.

Similarly, Jameson (1961) reported that Arceuthobium americanum in Jack pine in Saskatchewan was usually confined to the poorest of 5 site classes recognized. It was occasionally found on the 2 intermediate sites, but not on the 2 best sites. However, John Laut's current studies have not confirmed this site relationship for Jack pine mistletoe.

Ground Cover: There have been few attampts to correlate dwarf mistletoe occurrence with understory vegetation. The best example of this work is by Daubenmire (1961) in ponderosa pine in the Inland Empire. He reported that dwarf mistletoe occurred only on the Pinus/Agropyron and Pinus/Purshia habitat types. As previously mentioned, these were the 2 driest of 7 habitat types recognized.

Another report of association of dwarf mistletoe and habitat type is by Dowding (1929) for Arceuthobium americanum on Jack pine in central Alberta. She reported that the parasite was much more abundant in the "pine-moss" type than in the "pine-heath" type. However, John Laut has not been able to confirm this relationship in Manitoba and Saskatchewan.

We have been studying the ground cover vegetation in infected vs. healthy lodgepole pine stands in the central Rockies. There are striking relationships between ground cover and site quality but, so far, we have not discovered any consistent relationship between ground cover and occurrence or abundance of mistletoe.

Elevation: One aspect that we have fairly good data on in our area is elevational distribution of the dwarf mistletoes. For A. vaginatum on ponderosa pine, mistletoe is most abundant at medial elevations of the type. It is very rare in low elevational, marginal stands (Hawksworth 1959).

However, lodgepole pine dwarf mistletoe does occur at the lower limits of the type, but not at the upper limits. In general, there is a mistletoe-free zone of about 500 feet between the upper limits of mistletoe and the upper commerical limits of lodgepole pine (Hawksworth 1956). Recently, John Laut and I have started studies that we hope will give some clues to the reasons for this zone. We have transplanted mistletoe-infected lodgepole pines into this zone near a weather station at 10,000 feet in northern Colorado. Tentative observations after the first summer, based on observations made in late October, suggest that mistletoe fruits did not mature in this mistletoe-free zone. Perhaps the growing season is so short that it effectively limits the development of the parasite.

General observations also suggest that there is a similar upper limit to the Douglas-fir dwarf mistletoe in the central and southern Rockies although we have not studied this in detail.

TREE FACTORS

The possibility of genetic resistance playing a role in the absence of dwarf mistletoes from certain parts of their hosts' range (Roth 1966) should not be overlooked although the evidence to date suggests that this is not a deciding factor. For example, we have successfully inoculated ponderosa pine from the Black Hills of South Dakota with the A. vaginatum (Hawksworth 1963), and Ed Wicker has inoculated west-side Douglas fir with A. douglasii (Wicker, in press).

A very intriguing feature of dwarf mistletoe parasitism that we have observed in the Rocky Mountains is a type exclusion such that if the principal parasite of a tree is present in a stand, parasitism of that tree by other species of dwarf mistletoe will be rare (Hawksworth 1968a). Conversely, if the principal parasite is absent, the tree may be frequently parasitized by other mistletoes. I have two examples to illustrate this phenomenon:

Stands with A. vaginatum subsp. cryptopodum (Principal parasite)	Stands	A. americanum on Pinus ponderosa	
		Number of trees examined within 20 feet of infected Pinus contorta	Percent of trees infected by Arceuthobium americanum
Yes	3	92	13
No	16	567	64

Stands with A. americanum subsp. (Principal parasite)	Stands	A. vaginatum on Pinus contorta	
		Number of trees examined within 20 feet of infected Pinus ponderosa	Percent of trees infected by Arceuthobium vaginatum
Yes	3	131	5
No	5	265	23

Thus, in both instances, the proportion of trees infected by the secondary parasite was almost five times as high in stands where the principal parasite was absent as where it was present. This type of situation is apparent between most host-parasite combinations in the Rocky Mountain Area. The reasons for this exclusion are unknown and our preliminary investigations have dealt primarily on determining whether such situations are real or apparent.

CONCLUSIONS

The dwarf mistletoe-host association is a long and intimate one developed over countless ages. Probably, the dwarf mistletoes have become established in most areas that are climatically suited to their survival, but there seem to be some exceptions to this. Many ecological factors are associated with mistletoe distribution: stand history (fire, cutting, catastrophies); climatic effects; site factors (topography, soils, site quality, ground cover, elevation) and tree factors (genetic resistance, exclusion). For the most part, the role of these factors in mistletoe distribution remains to be investigated.

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SOME IMPRESSIONS CONCERNING THE ABSENCE OF *ARCEUTHOBIUM DOUGLASII* FROM THE FLORA OF WESTERN WASHINGTON AND OREGON

Ed. F. Wicker

You will notice some similarity in what I have to say and what has been discussed in the preceding two papers, although the terminology will be quite different and perhaps new to some of you. This similarity is entirely coincidental. I had not read nor heard these papers prior to their presentation today, nor have their authors read or heard my presentation.

It is considered to be general and factual knowledge that the dwarf mistletoe *Arceuthobium Douglasii* Engelm. does not occur on conifers growing west of the Cascade Crest in Washington and Oregon north of the

Siskiyou Mountains nor west of the Coast Range in British Columbia. Neither does it occur east of the Continental Divide in Montana, Wyoming or Northern Colorado, but it does cross the divide in Central Colorado, causing severe damage to Douglas fir in the Southern Rockies. The absence of A. Douglasii on Douglas fir growing in these areas has generated a conception of genetic immunity which without a factual and demonstrable foundation is mere supposition. However, explanations for the absence of this parasite in these areas might provide a knowledgeable basis for future control recommendations.

Results from my own research during the past 8 years show that seedlings of Douglas fir obtained from the two A. Douglasii free areas are genetically susceptible to the parasite when grown under greenhouse conditions, and that seedlings of Douglas fir gorwing in their natural habitat west of the Cascade Crest in Washington are likewise susceptible. I suspect that the Douglas fir growing east of the continental divide in Montana, Wyoming and northern Colorado is similarly susceptible although this has not been tested.

Since time will not permit a discussion of both areas, I have chosen to spend the next 20-30 minutes discussing the orogeny, geography and ecology of the area west of the Cascade Crest in Washington and Oregon, and the relation of these factors to the absence of A. Douglasii from the flora. Before such a discussion is possible there are certain biological characteristics of A. Douglasii and Douglas fir and certain ecological principles which must be considered.

Arceuthobium Douglasii is an obligate parasite and has a very narrow host range. The principal host is Douglas fir. Rarely is this dwarf mistletoe found on other hosts and sustained propagation on these other hosts is certainly doubtful. Thus the distribution of A. Douglasii is directly dependent upon the distribution of Douglas fir. This fact greatly restricts its ecologic amplitude and stresses the importance of the ecology of Douglas fir to the distribution of Arceuthobium Douglasii.

When we consider the ecologic adaptability of A. Douglasii as

this relates to the colonization (invasion) ability (immigration, establishment and propagation) and the competitive capacity of a plant species, we find that such factors as the type of disseminules produced, method of dissemination, infectivity, metabolic and photosynthetic capability, plasticity and genetic stability further restrict the ecologic amplitude of this species.

When we examine the evolutionary characteristics and ecologic adaptability of the principal host of this dwarf mistletoe, we find considerable heterogeneity which supports an ecologic amplitude sufficiently broad to enable the species to invade numerous ecotopes.

Let us move now to a discussion of the genesis and evolution of seres (succession) which have occurred and are still occurring, within the geographic area being discussed, in which Douglas fir is a component of the phytocoenosis. In order to do this we must first consider some of the physiographic processes which have produced the raw geologic formation which provides the rooting medium necessary for the initiation of a sere.

It is concluded from geologic data that at one time or another every part of the land surface has been bare of vegetation, the area with which we are concerned being no exception. Formation of the mountains in Western North America is believed to have occurred during the Pliocene Epoch of the late tertiary period, some 1 - 12 million years ago. It is during this period that modern plants and animals are believed to have developed. The Cenozoic History of the region west of the Columbia Plateau and the Basin and Range Province of Arizona and New Mexico is very complex and extremely difficult to understand. The region encompasses two great mountain ranges separated by numerous large troughs. The eastern mountain chain consists of the Cascades and Sierra Nevada; the Coast Range makes up the western chain. As the coast range was folding and faulting, the troughs between these two mountain ranges were repeatedly invaded by the sea. The Cenozoic record implies a period of extraordinary crustal disturbance and volcanic activity in Western North America, intermittently, to culmination in the regional uplift of the pleistocene referred to as the Cascadian Revolution. The Cascade Mountains were in the midst of these complex

vertical movements. Faulting was common, with folding restricted to the Puget Sound and Coast Range.

Only extensive glaciation differentiates the pleistocene from the pliocene. Events of the pleistocene have had a profound and direct impact upon the modern world. It was during this epoch that early man appeared and the ice sheets covered large parts of the Northern Hemisphere. Glaciation stripped away the soil from some regions, caused inundation of others and deposited till over still others, thus providing a finishing touch to the modern landscape. Three major ice sheets were present in the Northern Hemisphere. In this discussion we are concerned only with one, the cordilleran complex. Glacial development was not continuous but rather intermittent with recessions. Four ice ages are now recognized, the last one being designated the Wisconsin. The intervening warm interglacial periods were of such duration as to permit the migration of plants and animals from warm temperate climates and refugia, onto the glaciated regions. Thus their ranges were extended during these periods only to be contracted, fragmented or isolated during a subsequent ice age.

During the Wisconsin Ice Age (11, - 35,000 years ago) the Vashon lobe of the cordilleran complex extended to cover the Puget Sound country of western Washington, and Montane Glaciers covered the Cascade and Coast Ranges of Washington and Oregon. Through erosion, deposition, inundation and climatic influences, these masses of ice exerted a profound influence on the region far beyond that portion covered and subsequently glaciated by ice. The proximity of the region to the Pacific Ocean certainly had an ameliorating effect on the glacial influences because the marine influence on climate has been a stabilizing one.

Palynologic data from pleistocene depositions in western Washington and Oregon provide an insight to the more recent origin and succession of plant seres within the region. Interpretations of evidence from pollen profiles relating to forest succession are necessarily conditioned by the method of analysis, but consideration of the ecologic characteristics of the species concerned permits conclusion of some logical and possible sequence of past forest succession. Local

weather, pyric influence, and the local action of biotic agents including man, contribute the distortion of the regional picture but are actually of minor reflection in the pollen profile.

Pollen profiles of the Puget Sound of western Washington have been used by several workers as a basis of comparison for the interpretation of profiles from other regions of the Pacific Northwest, because the Puget Sound is rather homogenous in regard to ecological conditions.

Following recession of the vashon ice, it has been concluded from the data available that lodgepole pine was the pioneer tree invader. The ecologic characteristics of this species very likely permitted its invasion of the unstabilized conditions near the receding ice edge, a position of minor competition. This invasion by lodgepole pine had a stabilizing effect on the edaphic and physiographic conditions which permitted the invasion of more tolerant and longer lived species such as western white pine, Douglas fir and finally western hemlock. This is the sequence indicated from analyses of post-Wisconsin pollen profiles and also the sequence indicated by study of current vegetation. A predominance of lodgepole gives way to white pine which in turn is replaced by Douglas fir which western hemlock supersedes.

As should be expected, we find some variation in post-Wisconsin forest succession pattern between regions within the Pacific Northwest, this variation being attributable to edaphic, phyric, climatic and physiographic conditions. Thus in the prairie areas south of the Puget Sound the frequency of predominance of Douglas fir indicates greater periods of range expansion and contraction. On these areas Douglas fir has never been replaced by western hemlock and oak has entered the competition. In the Willamette Valley of Oregon we find a similar successional pattern where western hemlock has never been abundant during post glacial periods, and we find an invasion of white oak at the expense of the mesophytic species, including Douglas fir. Factors affecting forest succession on the pacific coast are not so clearly recorded in geologic time and do not always agree chronologically. It would appear that the forest vegetation frequently fluctuated because of physiographic and edaphic instability. Sand dune and pyric influences also contributed to

this state of flux. The marine climate undoubtedly has had a stabilizing effect on regional changes of forest vegetation along the coast. Sitka spruce succeeds lodgepole pine in the coastal forest. Douglas fir never has shown a predominance although it has been and is currently represented in the flora of the area.

In contrast, the pre-Wisconsin interglacial palynologic data from the Puget Sound shows a major difference in pollen chronology which records a predominance of Abies and Picea in the forest succession pattern and no predominance of Douglas fir, although the species was present.

Thus there is evidence which indicates that Douglas fir has been represented in the forest vegetation of western Oregon and Washington since pre-Wisconsin time. Yet there is no evidence that A. Douglasii has established its parasitic relationship with this conifer in this particular geographic area.

While the explanation as to the reason for the absence of A. Douglasii in the flora remains shrouded in the mist of the past, there exists evidence which contributes to some possible and logical impressions. When we look at the physiographic features of western Oregon and Washington, we see an area surrounded by mountains giving way to the Pacific Ocean on the west which exerts a stabilizing influence on climate. Flowing from these mountains, towards the ocean, are numerous streams. While these physiographic features have definitely served as highways for migration of some plants, they also function as highly effective barriers for the migration of others. The method of dissemination and the requirements for invasion of A. Douglasii renders this plant a suspect victim of such barriers. This suspicion has a direct basis in the nature and character of the ecology of the parasite, and perhaps an indirect basis of even greater magnitude in the ecologic amplitude of the principal host, Douglas fir. Even with an ecologic amplitude sufficiently broad to permit invasion of several diverse ecotopes, it does not invade all ecotopes to form a continuous distributional pattern. Thus host range fragmentation may represent an effective barrier to invasion by the parasite.

Forest succession has a profound impact upon the distribution of A. Douglasii and its perpetual status in the ecosystem. The successional status of Douglas fir is one character of the vegetation

which must be considered. The status of Douglas fir may be seral in some habitat types and climax in others. In the absence of disturbances in succession, the term seral connotates a temporary occupancy and climax connotates a permanent and perpetual occupancy. Thus, because of the obligate and dependent relation of A. Douglasii to Douglas fir, the successional status of Douglas fir in a given habitat type becomes a very significant factor influencing the invasion and perpetuation of the parasite.

There is one final impression which I wish to leave with you. As plant pathologists and as foresters, we have the tendency to apply and interpret susceptibility, resistance and immunity in terms of genetic composition of a species or an individual. This is unfortunate indeed because the usefulness of these terms to us ends right there, and yet there exists both a need and a basis for the broader application of such terms. There is living evidence that dwarf mistletoes are far more intense and damaging in certain habitat types than in others--all in which the principal host reaches predominance at some stage in the development of the sere. We cannot explain this difference on the basis of genetic variation as it relates to susceptibility and resistance of the host. The fact that a genetic suscept exists in the habitat types does not insure invasion and perpetuation of the pathogen. The existence of such genetic suscepts is best considered a necessary prerequisite for invasion just as a source of inoculum is a prerequisite. The remaining requirement is environment. It is at this point that we must project our thinking to include the entire ecosystem. We can no longer draw meaningful correlations between individual plants and individual factors, because we are concerned and working with entire plant communities. The vicissitude of change and interactions make the community and its environment inseparable. This will, in turn, regulate floristic composition. Herein, we find a basis for the application of the terms susceptibility, resistance and immunity to ecosystems and subdivisions thereof. Thus is life and the secrets and suspense of time.

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POSSIBLE EFFECTS OF FOREST SUCCESSION ON THE DISTRIBUTION OF DOUGLAS-FIR DWARF MISTLETOE IN BRITISH COLUMBIA

R. B. Smith

INTRODUCTION

Douglas-fir dwarf mistletoe (Arceuthobium douglasii Engelm.) extends from southern British Columbia to approximately 600 miles south of the Mexican border (Hawksworth and Wiens 1965). Its occurrence in British Columbia represents the extreme northern fringe of its range. Here, the main infected area extends in a tongue-like fashion 100 miles north of the U. S. border. It includes much of the Similkameen and

Okanagan Valleys and is likely contiguous with more extensive infected areas in the U. S. Another infected area occurs at the southern end of Kootenay Lake extending 25 miles north of the U. S. border. It also appears to be adjacent to infected areas in the U. S. (Graham 1960). A small infection center occurs at Big Sheep Creek between Rossland and Grand Forks only a few miles north of the border (Kuijt 1963). I have failed to locate this area but Kuijt felt that it was sufficiently discrete to suggest dispersal by birds. An isolated area of infection occurs near Lytton at the confluence of the Thompson and Fraser Rivers. This is the most western location known (Long. 121° 30'; 50° 15'). Another isolated area near Sicamous, 125 miles north of the border (Long. 119° 0'; Lat. 50° 50'), is the most northerly distribution of Douglas-fir mistletoe known, though Douglas fir extends north another 300 miles.

In general, Douglas-fir dwarf mistletoe occurs in the wetter portion of the Ponderosa Pine Zone (Krajina 1965) and in adjacent portions of the Douglas fir Zone. Extremely low annual and summer (May through August) precipitation occurs at main stations in the Similkameen and southern Okanagan Valleys and at Lytton (Table 1). Somewhat wetter conditions prevail in the North Okanagan, Kootenay Lake and Big Sheep Creek areas but summer precipitation remains low. After being conditioned to an association of Douglas-fir dwarf mistletoe with some of the driest areas of British Columbia, it was interesting to learn of a report, made in 1960 but not confirmed until 1966, of Douglas-fir mistletoe near Sicamous in the relatively wet Western Hemlock Zone. A reconnaissance of the area in 1966 revealed that most of the mistletoe occurred on a steep (up to 37°) south-facing slope. This appeared to be a good opportunity to explore the effect of exposure on stand composition and on the distribution of dwarf mistletoe.

METHODS

Two parallel strips four chains (1ch. = 66ft.) apart were run from the bottom of the south-facing slope over a ridge and down into a north- to northwest-facing slope. On Strip I (18 ch. long) five plots were established to enable stand tallies and estimates of the abundance of minor vegetation. In addition, the basal area of all

tree species was estimated with a relascope at two-chain intervals along the Strips I and II. Mistletoe was rated on all Douglas fir tallied in the plots and in the basal area survey using Shea's (1963) 4-point system. Some air temperature data are being gained from maximum-minimum thermometers established in each of the 5 plots.

TABLE 1. Precipitation in areas of Douglas-fir dwarf mistletoe in British Columbia.

Area	Zone	Average annual precipitation-inches	Average monthly summer precipitation-inches
South Okanagan and Similkameen	Ponderosa Pine	11.7	1.0
Lytton	Ponderosa Pine	18.3	0.8
North Okanagan	Douglas fir	16.2	1.3
Kootenay Lake	Douglas fir	18.9	1.2
Big Sheep Creek (Rossland)	Douglas fir	31.7	1.2
Sicamous	Western Hemlock	25.5	2.1

RESULTS

Recent fire history appeared similar throughout the study area. Douglas-fir trees up to 200 years of age occurred in all but Plot 4 where mortality of large Douglas fir was high.

The total number of trees per acre increased from 875 in Plot 1 to 5970 in Plot 5. Douglas fir decreased from 91% of the live trees in Plot 1 to 15% in Plot 5, while western red cedar was absent in Plots 1 and 2 and increased to 65% in Plot 5 (Table 2.) Western hemlock was absent in Plots 1 to 3, rare in Plot 4 but common (14%) in Plot 5. Birch and maple were most abundant in plots with cool exposures and willow and cherry in plots with warm exposures.

The composition of Douglas fir over 1-inch d.b.h. by basal area also decreased from Plot 1 to Plot 5 (Table 2). As measured with relascope, the basal area of live Douglas fir on Strip I ranged from 100% on the south-

facing slope to as low as 8% at the end of the strip on the north-facing slope. On Strip II (14 ch. long) the composition of Douglas fir varied from 100% to 50%. The less drastic reduction in Douglas fir was possibly because Strip II ended on a west rather than a north-facing slope.

TABLE 2. Composition of live trees in plots by number and basal area

Plot	Position on strip ch.	Slope deg.	Exposure	SPECIES[1/] F No. %	F BA %	C No. %	C BA %	H No. %	H BA %	Bi + M No. %	Bi + M BA %	W + ch No. %	W + ch BA %
1	1 - 2	31	S	91	98	0	0	0	0	0	0	0	0
2	4 - 5	26	SW	81	88	0	0	0	0	2	2	15	0
3	8 - 9	16	NW	31	47	42	33	0	0	25	20	0	0
4	11 -12	6	W	35	9	44	40	1	0	18	51	0	0
5	16 -17	22	N	15	35	65	40	14	5	2	20	0	0

[1/] F = Douglas fir; C - Western red cedar; H - Western hemlock
Bi = Western white birch; M - Douglas maple; W = Willow;
Ch = Cherry

In addition to the tree layer, striking differences occurred between the minor vegetation in Plots 1 and 2 and Plots 3, 4 and 5. Grasses (Danthonia spicata, Festuca occidentalis, Calamagrostis rubescens, Elymus glaucus) were abundant in the former plots but absent in the latter 3. In plots 3 - 5 the common plants included Aralia nudicaulis, Chimaphila umbellata, Linnaea borealis, Clintonia uniflora, Pyrola secunda, Goodyera oblongifolia, and a considerable cover of mosses, primarily Rhytidiadelphus triquetrus, Pleurozium schreberi and Hylocomium splendens. Juniperus scopulorum and J. communis occured only in Plots 1 and 2 while Taxus brevifolia occurred only in Plots 3, 4 and 5.

Measurements of maximum temperatures for 4 periods between July 3 and September 13/68 indicated that maximum temperatures were 5 to 11° higher on the south-facing slope than on the others.

Dwarf mistletoe was present only in Plots 1, 2 and 3. It was

severest in Plot 2 in which 73% of all living Douglas fir were infected (48% lightly, 22% moderately, 22% severely, and 8% severely and with a dead top). The basal area survey showed a similar pattern with the highest amount of dwarf mistletoe occurring in the 4 chain area of Strip I and in the 1 and 2 chain areas of Strip II. No dwarf mistletoe was found past chain 10 on Strip I or past chain 8 on Strip II.

DISCUSSION

The south-facing slope represents an intrusion of the Douglas-Fir Zone into the Hemlock Zone. It possesses characteristics which would obtain in many topographic situations in the median part of the Douglas-fir Zone. While considerable regeneration of Douglas fir occurs on all slopes in the Sicamous area, only on warm exposures does Douglas fir survive as a dominant species in mature stands. On these warm slopes little change in tree composition is expected as the stands mature; they are very near a climax type now. In contrast, on cooler slopes in this Zone, western red cedar and western hemlock are abundant in the early stages of stand development and tend to increase in importance as the Douglas fir dies and the stand develops toward the climax stage.

Because dwarf mistletoe spreads slowly, the composition of stands not only today but also in the past must be considered. Long undisturbed periods may have formerly occurred, resulting in almost pure cedar-hemlock stands on the cool exposures, but not changing to any appreciable extent the Douglas-fir dominant stands on the south slope. Starting with an equal population of dwarf mistletoe on opposite slopes, it is suggested that mistletoe would intensify on the south slope and because of a gradual disappearance of the host itself, decrease on the north slope. It follows that correlations between various topographic features and dwarf mistletoe occurrence should be made with some cognizance of forest succession. In the median part of a zone successional trends may not differ significantly from one topographic position to another, but on the fringes of zones the development of a species is finely tuned to environmental differences.

Under natural conditions in the Western Hemlock Zone, Douglas-fir dwarf mistletoe has difficulty spreading on to cool slopes. The

infection center at Sicamous is thus somewhat self-isolating. However, harvesting at a relatively early stage of stand development would set up new conditions favoring Douglas fir, and thus Douglas-fir mistletoe. Such harvesting would have to be accompanied by sanitation measures if spread of the mistletoe from its present position is to be minimized.

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WORKSHOP GROUP I.--AIR POLLUTION

Paul R. Miller, Leader

The occurrences of air pollution damage to forest trees in the Pacific Northwest, as currently reported, are confined to point sources of fluoride from aluminum reduction plants and sulfur dioxide from copper smelters or coal burning power plants. In contrast, forest damage in the Pacific Southwest is due to oxidant type pollution from area sources represented by populous areas like the Los Angeles basin. In the southwest the conifer forests do not occupy extensive, uninterrupted areas as they do in the northwest because of elevational limitations, etc. Recreational pressure on forests, particularly in the southern half of California, is already great and is increasing; therefore, trees assume a value far beyond that as simply a source of cellulose.

The participants reported incidents of injury by accidental escape of chlorine at an industrial site and sulfuric acid aerosol from a munitions plant. Injury to western red cedar and maple in the vicinity of Kraft pulp mills was suggested but the exact toxicant was unknown. Roadside damage due to salt accumulation following winter applications to the road was commonly reported. This type of injury to conifers can be confused with the symptoms of SO_2, Fluoride, chlorine and higher concentrations of ozone so that caution must be used in diagnosis. A needle dieback of ponderosa and Austrian pine in and near Denver, Colorado was first suspected to be an air pollution problem, but recent evidence indicated that salt is accumulated from water used to sprinkle irrigate trees and lawns in parks and golf courses.

Forest pathologists are in a unique position to be the first aware of an impending community air pollution problem because conifers in particular are sensitive bio-indicators of elevated concentrations of several important pollutants. They reveal the accumulative effect of pollutants for several preceding years on the older needle whorls retained. Conifers can be maintained more easily for longer periods as container plants in the forested areas of suspected pollution than can tobacco and

petunia, for example. Tobacco is a good indicator of ozone damage, petunia for the oxidant peroxy acetyl nitrate and gladiolis for fluoride. Vegetative clones of eastern white pine, which exhibit selective sensitivity to either ozone, fluoride or sulfur dioxide have been selected. Christmas tree plantations are excellent places to look for suspected pollution damage.

Little if anything can be done to protect forest species from air pollutants after the problem has become chronic. Early detection of injury with native or placed indicator plants provides valuable evidence to promote the installation of emission control devices on point sources of pollutants such as smelters and aluminum reduction plants. In the case of area sources of oxidant type pollution, this information will hopefully hasten the application of technology and institution of laws to reduce pollutant emission from automobiles - the principal source.

An aluminum company wishing to establish a new ore reduction plant in Oregon is planning an aerial and ground survey of vegetation surrounding the proposed site. This will help quantify any subsequent damage and, more important, will set a standard of emission control which must be maintained. This is another opportunity where the participation of forest pathologists can help control a pollution hazard.

The role of the forest industry as a polluter of the atmosphere was discussed. Slash burning, smoke from teepee burners at sawmills, particulate material from sanders and various gaseous effluents from Kraft pulp mills are examples. It has not been clearly demonstrated that any of the above-mentioned effluents are toxic to forest species but people register definite objections to chronic pollution of these types.

Alternate methods of forest waste disposal were reported. Logged lodgepole pine stands in the northwest have been chopped back into the soil by huge rollers with blades. Even those trees which remained standing were knocked down. This practice controls mistletoe, prevents excess reproduction because of the incorporated residue and minimizes the fire hazard.

Control devices are being applied to saw and particle board mills at Anderson and Redding, California. The teepee burner has been improved by increasing the internal combustion temperature with a refractory brick cylinder placed inside.

Air pollution can no longer be categorized as strictly an urban problem. Forests which are fifty miles distant can be the unfortunate recipients of damaging oxidants. Participants indicated the need for a well-illustrated compendium of the symptoms of injury by specific pollutants to forest species. Early recognition of air pollution injury will hasten the necessary control practices.

WORKSHOP GROUP II COST:BENEFIT RATIO

Donald P. Graham, Leader

The workshop on cost/benefit was attended by 12 members. Presence of members from Canada and the United States, and from Research as well as Pest Control, provided a favorable opportunity to cover the various aspects of the subject. We discussed costs, benefits, and finally the cost/benefit analysis (ratio).

Following is a brief resumé of highlights:

1. We were at a distinct disadvantage in that no one had any expertise, and only limited or no experience regarding the topic. However, general agreement was reached on several points.

2. There was concern among all about needs and methods to arrive at meaningful cost/benefit analysis in order to justify our work. The pressure is on in the United States and Canada.

3. Disease research and survey-control scientists must take considerable leadership in justifing their work through meaningful cost/benefit analysis. If not, others will do it for us. It was agreed, however, that we must seek assistance and input from others, especially the economist.

4. We agreed that we must be as fair and equitable as possible and use all the expertise we have or can get from others to obtain sound cost/benefit ratio.

5. Agreed that we must work to make sure our superiors are receptive to our assessment of cost/benefit, even though we may not have overwhelming evidence on accuracy of the costs or the benefits.

6. The cost/benefit ratio, whether disease suppression or research, should always be favorable, but not necessarily on the timber resource alone. On land where timber will be utilized as a salable product, the timber resource usually should be the major factor in cost/benefit evaluation. But any other resource values that will be protected or saved must also be used in the assessment.

7. We agreed that for certain diseases where huge losses are obvious, long involved, time-consuming and costly cost/benefit analysis is not necessary.

8. When we attempt to balance various costs and benefits, the result is likely to be a sense of uncertainty. We simply do not know effective ways of measuring the magnitude of the costs and the benefits which would be associated with an extensive research project or suppression project. Lack of impact data is a major roadblock.

9. It was the concensus of the group that a topic on this matter, that is, cost/benefit assessment, would be a good subject for a future meeting. If such a panel presentation is arranged, the economist and others should be invited to take part as needed.

Preparing a write-up from notes or memory following a workshop of this type is always dangerous. I take full responsibility for any unintentional misinterpretation in recording what took place.

In conclusion, I hope everyone who attended the workshop received some benefit from the discussions.

WORKSHOP GROUP III REMOTE SENSING IN FOREST PATHOLOGY

J. F. Wear, Leader

The application of remote sensing techniques to forest disease problems is relatively new. Only in the past few years has a concentrated effort been made to apply some of these techniques (primarily aerial

photography with special film-filter combinations) to increase the efficiency of forest disease surveys. Many of the new remote sensing techniques are tied in with our space age technology and are in the research and developmental stages. Although some techniques have been available for some time, forest pathologists have not exploited them to the same degree as have the forest entomologists. An exception to this is the excellent work being done by Mr. Joe Baranyay in maximizing aerial photography to provide more definitive answers on the dwarf mistletoe problem in lodgepole pine (1). Mr. Baranyay will describe his work shortly.

The objectives of this remote sensing discussion are:

1. To examine remote sensing techniques that are currently available and operational for assessing disease problems,

2. To outline the types of remote sensing research studies on disease now in progress,

3. To obtain ideas and specific needs from you on critical disease problems in which remote sensing could help,

4. To speculate on future developments and promising leads that may simplify or answer forest disease questions.

To understand remote sensing techniques more clearly, it is necessary to look at the basic divisions of the electromagnetic spectrum and determine the parts more likely to provide useful information. The visible spectrum is a very small part of the total as you can see on the slide diagram. This visible or photographic portion ranges from .3 to .9 microns and includes the panchromatic, color, color infrared, and infrared photographic films. Individual slides of each film type in the same area illustrate how the various landforms and vegetative cover can be delineated. The appearance of an area on thermal infrared imagery (8· to 14 micron band) and radar imagery indicates poorer resolution than standard photos but serves specific purposes very well. It is apparent from the slides shown that the color infrared (Ektachrome IR) film has the broadest range of colors to discriminate soil and moisture patterns and various types of herbaceous and vegetative plant communities. In the visible portion of the spectrum, I believe that color infrared film has the best potential for evaluating forest disease parameters

and detecting trees under stress.

Meyer and French find color infrared film best for differentiating mistletoe infection centers in black spruce stands of north-central Minnesota (2). They recommend a photo scale about 1: 7,000. Dutch elm disease is also discernable with this film at a scale of approximately 1 : 9,600. 1 : 6,000 scale Ektachrome infrared film has been found to provide good detection of oak wilt infections in southeastern Minnesota. The incidence of disease in hardwoods has generally been detected more readily and accurately than in conifers because of the more pronounced physiological changes occurring in the leaf structure. Aerial remote sensing techniques and survey procedure for evaluating major diseases in conifers are in the R and D stage. Visual surveys for dwarf mistletoe in Douglas-fir have proved effective from helicopters at low altitude in R-6. Dr. Baranyay will now explain his photographic experiences with the dwarf mistletoe problem in lodgepole pine.

Dr. Baranyay has presented an interesting talk on how he has used aerial photographic methods to evaluate dwarf mistletoe activity in lodgepole pine. He is to be commended for an outstanding effort in applying a remote sensing technique to solve this disease problem. A brief resume of the key points from his discourse are as follows:

1. Panchromatic photography is unsuitable for differentiating infected from healthy trees regardless of the mistletoe severity.

2. 1 : 7,920 scale Ektachrome Aero color provide imagery that will discriminate heavy infection centers. 1 : 2,400 scale is suitable for detecting dying trees, discolored foliage and branches, and witches brooms.

3. Various infection classes could not be identified without foliage discoloration in the tree on the Ektachrome Aero color film.

4. Ektachrome Infrared color film, although underexposed on this test, has the highest potential of discriminating diseased from healthy lodgepole pine trees.

5. Quality control of aerial photography provided by contractors is a critical problem that remains to be solved.

Remote sensing research is being carried on in three general forest disease areas; Poria weirii root rot in Douglas-fir, dwarf mistletoe in ponderosa pine and lodgepole pine, and smog pollution damage to ponderosa

pine in southern California. Similar problems of trees under stress from various causes will be investigated in time.

The part of the spectrum that so far appears to have the greatest promise for discriminating healthy from Poria weirii root rot infected trees is thermal infrared in the 8 to 14 micron band. Significant to highly significant temperature differences have been recorded with a Barnes Engineering non-imaging PRT-5 radiometer at a distance of approximately 150 feet above the forest canopy. Aerial operations have been conducted from a semi-hovering helicopter on an individual tree basis. An orbiting pattern around each tree provided thermal readings on both the sun and shadow sides. A new technique that I have developed for helicopter operation is an integrated video scan and thermal infrared system (3) that could be used to survey large or small forest areas. The PRT-5 radiometer, boresighted to one vidicon camera, is operated from a vertically mounted pod on the side of the helicopter. A second vidicon camera takes pictures of a digital voltmeter that receives electronic readings from the thermal output from the PRT-5. This electronic output is fed through a special effects generator into the Ampex tape recorder and appears on each frame. Thus, a continuous thermal profile can be studied on instant replay video tape. The two-degree angle of view from the PRT-5 is superimposed on the video tape so that each tree with its corresponding temperature indication can be studied and identified for ground checking. This system is still in the development stages, but shows great promise for operational surveys.

Research and development studies of trees under strees from dwarf mistletoe and Fomes annosus in ponderosa pine, and various needle casts are in the preliminary planning and exploratory stages. The 1:1000 and 1:4000 scale 9 x 9 photos in Ektachrome IR of mistletoe in ponderosa pine look promising, especially in open stands where "brooming" is clearly visible in the tree shadows. Crown deterioration and dead branches are also obvious. Visual, photographic, and thermal infrared survey techniques will be included in the studies.

Dr. Paul Miller (WS Group I) is working with Bob Heller's Remote Sensing Research staff at PSW Experiment Station, Berkeley, testing various aerial film-filter combinations to determine the effect of air pollution (smog) on ponderosa pine. Miller will be summarizing the study

results later at this meeting.

You have had an opportunity to view some of the remote sensing tools and techniques that are currently being tested and developed for improving forest disease surveys. Review your forest disease problems to determine how remote sensing techniques might improve the efficiency of a research or survey operation. These techniques could greatly increase the quantity and quality of data needed to obtain definitive answers.

In conclusion, I'm sure that all of us realize that forest disease survey techniques are difficult to attain because of the slow rate of tree decline and the minimal of partial fading characteristics of trees affected by different diseases. However, the forest pathologist has tremendous opportunities to use currently available remote sensing techniques to solve many disease problems. Specific disease problems may require more sophisticated remote sensing techniques. However, the rapid pace of current space age technology and the research underway in Remote Sensing Research would clearly indicate significant improvements in disease survey techniques in the near future.

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WORKSHOP GROUP IV MODERN TECHNIQUES OF PATHOGEN IDENTIFICATION

Y. Hiratsuka, Leader

(No Report)

WORKSHOP GROUP V MANAGING FOREST STANDS FOR OTHER THAN TIMBER VALUES

J. M. Mahoney, Leader

For a point of departure for discussion, the new National Park Service concept of management defined in 1966 by A. Starker Leopold, was briefed. This was followed by a short synopsis of the new Service policy, developed in the light of the concept, which may be stated as managing natural park areas to continue that ecology which would have developed had the white man not interfered.

An attempt was made to relate research with specific problems in recreational forest management. Considerable discussion followed on detection and responsibility for removal of hazardous limbs and trees. The use of fire and some of its implications was explored particularly as related to National Parks. It was pointed out that most background research is in ponderosa pine types.

It was generally agreed that better communication between researchers and managers is vital. Further, managers must define and, as Joe Pechanec states "quantify the values" involved. The approach to research from economic versus natural ecology was brought up. All agreed that recreational problems accrue to all land managers and all need many answers. For instance, the impact of root rots and specific diseases in campgrounds needs to be studied.

The group had a lively period of discussion with the limited time available. No real solutions were forthcoming, but we found considerable common ground and directions research must take for recreational forest use if management can ask the right questions.

SPECIAL REPORTS

A NEW NEEDLE DISEASE OF PINE IN THE PACIFIC NORTHWEST

H. H. Bynum

A new needle disease of ponderosa pine has been found in Oregon. It was first observed in February 1967 in a 14-year-old plantation on the Tiller Ranger District of the Umpqua National Forest. It has since been found in two other plantations on the Umpqua, in an adjacent Bureau of Land Management plantations, and on the Rigdon Ranger District of the Willamette National Forest. D. R. Miller found this disease at about the same time on knobcone pine in the Redwood Experimental Forest in Del Norte County, California. Infection within the plantations is widespread and severe.

The disease is caused by an underscribed species of needle cast fungus in the genus Hypodermella. The new species is presently being studied and will be described by Dr. John M. Staley.

Needles of the current year are infected and become necrotic as early as the end of July. By February, and perhaps sooner, fruiting bodies of the fungus are formed on the red needles. These dark colored structures appear as discrete short lines or many coalesce and extend the full length of the needle. Infected needles become straw-colored and are cast during their second year, leaving the trees with a tufted appearance.

Trees that have been heavily infected for two or three years may appear to be dead until the new buds break in the spring. Some tree mortality has resulted from repeated heavy infection. Scattered individual trees appear to have varying degrees of resistance.

Trees in the plantations range in age from 12 to 21 years. All of the known areas of infection in Oregon are between 3,200 and 4,000 feet in elevation. Perhaps the temperature and humidity conditions at this elevational range favor infection. The infected knobcone pine in California is about eight years old and is growing at about 1,000 feet

elevation near the coast. In each of the Oregon areas, non-local seed sources were used and the ponderosa pine is off-site.

This new disease has appeared suddenly. Although its damage potential is not fully known, it seems quite capable of causing severe losses in at least two of our pine species. It is particularly damaging because it attacks and kills the newest needles of young trees.

PRELIMINARY OBSERVATIONS ON THE DISTRIBUTION, INTENSITY, AND IDENTITY OF THE LARCH CANKER DISEASE

Clinton E. Carlson and Harvey V. Toko

INTRODUCTION

Since 1950, emphasis toward more intensive management of western larch (Larix occidentalis Nuttall) has been advocated by the U. S. Forest Service in the Northern Region. Cutting practices and site preparation for regeneration have favored larch in nearly all areas where it was the predominant timber species and, as a result, numerous stands 5 to 20 years old now exist. Larch has traditionally been regarded as highly disease resistant; however, observation during the past 3 years suggests these young stands may be more disease-vulnerable than thought in the past. A stem canker, very serious in some areas, has been found throughout the western larch timber type in Region 1. As a result, the present study was designed to determine the distribution, intensity and identity of the stem disease. This paper is a preliminary report of the study.

Symptoms include a flattened, sunken appearance in the diseased area on the stem, generally sharply delineating the canker margin. The needles of a girdled tree prematurely turn color above the diseased area, resulting in a bi-colored tree readily seen at a distance. This condition has been named "carrot-top larch."

LITERATURE

Shaw (1958) indicated that Phoma sp. and Valsa abietis have been found on western larch in the Pacific Northwest. Wicker (1965) identified

Phomopsis pseudotsugae as the causal agent of cankers he found on larch on the Colville, Kaniksu, Coeur d'Alene and Clearwater Forests in Region 1. This represents the formal work accomplished to date on the larch canker problem in the Inland Empire. Estimates on distribution and of amount of damage have not previously been made.

METHODS

The study is divided in three parts:

1. General Distribution of the disease.
2. Intensity in individual stands.
3. Determination of the pathogen.

1. General distribution of larch canker.--Samples of cankered larch were collected on the Clearwater, Coeur d'Alene, Kaniksu, Kootenai and St. Joe Forests of Idaho, and the Lolo, Bitterrot and Flathead National Forests of western Montana. Forty-one stands were sampled, distributed relatively evenly throughout all the Forests.

2. Intensity in individual stands.--Several larch stands currently under management are being surveyed to estimate the intensity of the disease. A modification of the survey techniques used to estimate intensity of white pine blister rust in Region 1 (Clutter, 1966) is being used. The survey was designed to estimate the proportion of stems girdled and the proportion infected to a reliability of ± 20 percent at the 95 percent level of confidence.

3. Determination of the pathogen.--It was suspected that more than one fungus may be responsible for causing canker symptoms on western larch; thus, all cankers sampled in the general survey were brought to the laboratory, tissue removed from each of two positions on the margin of each canker, transferred aseptically to sterile PDA and allowed to incubate. Any fruiting bodies associated with the canker were surface sterilized and placed on PDA. Control consisted of inoculating PDA with apparently healthy tissue. In each of the months July, August, September and October, 1968, 49 trees were inoculated, two inoculations per tree, to establish pathogenicity and identity of the organisms associated with larch canker. The inverted "V" technique was used, employing as aseptic conditions as possible in the field. These inoculations, if successful,

will also be useful in determining expected damage caused by the disease.

RESULTS AND DISCUSSION

Description of the canker.--A total of 278 cankers were sampled in the 41 stands observed in the general survey. Visual signs and symptoms of all cankers were similar, consisting of slightly sunken, necrotic areas on the stem and exudation of resin from the margins. Small black pycnidia were often found. Very young infections often had no necrotic tissue, but a discolored purplish area associated with resin exudation was apparent.

Cankers were found in all stands, indicating the disease is widespread throughout western Montana, northern Idaho and eastern Washington. Infections similar to those on larch and producing identical symptoms were found on Douglas fir (Pseudotsuga meniesii (Mirb.) Franco) and grand fir (Abies grandis (Dougl.) Lindl.).

Intensive surveys.--Two stands have been surveyed intensively to date. A thinned stand on the Kootenai NF had 40 percent of the residual stand infected, with 30 percent of the infections girdling. A non-thinned stand on the Flathead NF had 40 percent infection. The data were reliable within the prescribed limits.

Determination of the pathogen.--Mycelial growth was obtained from all but 15 of the plates inoculated with canker tissue. Only one of the 42 control plates supported growth originating from the wood. A contamination factor of 5 percent was observed overall. Pycnidial cultures were always identical to those obtained from the corresponding canker margin, and represented the most common type of culture obtained. To date, plates have been sent to Funk in Canada and to Batra in Beltsville, Maryland. Funk identified the common-type culture as Lachnellula arida, while Batra identified a similar culture as Cephalosporium sp. On the basis of bark samples sent, Mr. Batra identified Valsa (Cytospora) abietis and Phomopsis sp. He also identified two other types of cultures as Peyronellaea spp. and Sphaeropsis sp., two morphologically closely related species. Pycnidia found on the cankers resemble those of the Phomopsis type. Lachnellula arida, an ascomycete, has been found associated with the dead tissue, and may be a causal organism, but it is probably only saprophytic on the necrotic tissue.

The artificial inoculations were made with the type of culture most often obtained; the Cephalosporium of Batra, Lachnellula of Funk, the pycnidial Phomopsis culture of Region 1, except in one case in which the Peyronellaea type was used. The 392 inoculations will be evaluated in 1969 and 1970.

It has been shown by the general survey that larch canker is distributed throughout Region 1. The data obtained from the intensive survey suggest the disease is very detrimental and could have serious management implications. Thirty percent girdled trees represents a sizable proportion of trees that probably will not reach rotation age. Future intermediate management practices in heavily infected stands should favor alternate species, if possible.

Identification of the causal agent or agents is a difficult problem. Perhaps more than one species of fungus is causing the canker, but it is also possible that the variations exhibited in the visual signs are caused by environmental differences and are not representations of true genetic differences. Much work remains to be done on this problem.

SUMMARY

The general distribution, intensity and identification of the larch canker disease is currently being evaluated in Region 1 of the U. S. Forest Service. The canker has been found in all stands examined, and in two it had infected 40 percent of the larch stems. Identification of the causal organism is confusing, but preliminary observations suggest it may be Phomopsis sp., Valsa (Cytospora) sp., Sphaeropsis sp., or Peyronellaea sp., or a complex of all.

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NATURAL INACTIVATION OF BLISTER RUST CANKERS ON WESTERN WHITE PINE

R. D. Hungerford

In 1966, we initiated studies to assess natural inactivation of blister rust cankers on western white pine. Today I am reporting on the preliminary results on one of these studies; i.e., the annual levels and trends of natural inactivation.

Cankers were tagged on white pine crop trees in stands not treated with antibiotics. Our canker base consists of 1,712 cankers on 49 plots in six national forests in the Inland Empire. These cankers are classed as lethal or non-lethal. On each plot a total of at least 10 lethal infections are being observed on a minimum of three trees.

At each examination a canker is recorded as active or inactive. For active cankers, the percent active margin is recorded as indicated by discoloration, fruiting or presence of Tuberculina maxima. If any of the above signs or symptoms are observed a canker is recorded as being active. Canker growth is also measured and recorded. As new cankers are found on the trees, they are tagged and added to our observed population.

Results of examinations to date are shown in Table 1. The percentages are levels of inactivation for lethal cankers. The annual levels column reflects the addition of new cankers at each examination. A more direct comparison between examinations and years can be made by looking at the base levels column. These percentages were computed for the original canker base used in 1966.

Dr. Kimmey conducted a preliminary survey of natural inactivation in 1965. We restricted our cankers to those on crop trees, consequently, we were not able to use all the cankers he used. The 1965 base column shows the level of inactivation for our examinations on those cankers of his that met our criteria.

Table 1.-- Levels of Natural Inactivation

	Levels %	No. Cankers	1966 base %	No. cankers	1965 base %	No cankers
1965	-	-	-	-	39.2	135
1966	16.1	575	16.2	567	16.3	135
1967-1	21.2	623	23.1	567	37.8	135
1968-1	23.0	727	28.4	567	47.4	135

A comparison of the inactivity for the various classes of cankers shows lethal branch cankers with 28.5%, bole cankers with 7.8% and non-lethal cankers with 35.2%. These figures are for our 1968-1 examination. Earlier examinations have shown slightly lower levels.

Closer examination of the data reveals that the inactive canker base varies from year to year, or within the same year. Active cankers become inactive while some of the inactive cankers revert to active cankers. These occurrences confirm the fact that we still have to follow cankers over time to assess their viability.

There is a positive correlation between canker age and inactivation. That is, the older the canker the more likely it is to be inactive. Seven of the plots have maintained a level of inactivation which was higher than the average level. I do not know whether these differences are significant, nor can I explain them now.

Although the level of natural inactivation on a canker basis is significant, the important question is, how many trees will be saved? Of the 262 trees examined in 1968, all lethal cankers on 13% (34 trees) were inactive. Only six trees with more than one lethal had all cankers inactive.

Selecting from our base of 1,712 cankers, we are studying permanency of inactivation; i. e., what is the destiny of a canker once it becomes inactive? Only cankers with a recorded active history are included. We will observe these cankers for 5 to 10 years then compute the probabilities of cankers remaining inactive, becoming active, and becoming dead. Of the 50 cankers now in this study, about 70% have remained inactive once they achieved this status.

A HEART BLUESTAIN IN CONIFERS

D. E. Etheridge

A heart bluestain similar to one reported from eastern balsam fir and cedar and caused by Kirschsteiniella thujina (Microthelia)(Mycologia 53 (2): 155-170. 1961) has been recorded on several western conifers during the past year. The stain and the associated fungus are briefly described below in the hope that additional records of hosts and distribution might be obtained.

The blue-grey discoloration of this stain characteristically occurs at the periphery of established heartrot columns caused by a wide variety of fungi. It occurs also as streaks at the bases of dead branches, frequently extending for distances of 1 to 2 inches into the buried portion of the branch. It is believed that the fungus gains entry into the heartwood through contact between the bluestain in the branch base and lateral extensions of rot columns in the heartwood.

Stained wood, both in radial and tangential section, displays numerous dark lines running at right angles to the wood elements, often continuing the characteristic pattern through adjacent areas of decayed wood. Sections of stained wood examined microscopically reveal long strands of thick, dark hyphae which are constricted where they pass through the walls of tracheids and rays.

On malt agar slants, the fungus produces abundant sterile, dark grey-olivaceous aerial mycelium. The colonies have abrupt, clear-cut margins, the reverse of the culture being black. Growth is slow, covering about two-thirds of the slant in 3-weeks, and usually ceases entirely before reaching the end of the tube.

During the past year, this stain/fungus association has been observed in Pseudotsuga menzeisii, Thuja plicata and Abies lasiocarpa. In addition, typical perithecia of the fungus (see Mycologia article) have been collected on dead, decorticated branches of Abies amabilis, A. concolor (in California) and Thuja plicata. The fungus has been isolated from the margin of decay infections in Douglas fir and western red cedar.

FLOURINE INJURY TO PONDEROSA PINE IN THE VICINITY OF SPOKANE, WASHINGTON

C. Gardner Shaw

An extensive "blighting" of ponderosa pine north of the city limits of Spokane, Washington was first noted in 1946 and 1947.

Dr. Folke Johnson, who had worked on flourine injury along the Columbia River (at Washougal and Troutdale), first tentatively diagnosed the cause after an aerial view of the Spokane area while on a commercial flight into Spokane.

With financed support from the City of Spokane and Spokane County, Washington State University and the U. S. Forest Service initiated an intensive investigation that continued from 1948-1953. Personnel involved were P. C. Johnson and J. C. Evenden - Entomologists, U. S. Forest Service; D. W. Lynch and C. Wellner, U. S. Forest Service; G. W. Fischer, G. G. Shaw, and J. W. Hendrix - Pathologists at Washington State University, and D. F. Adams and M. F. Adams - Chemists, Washington State University. The research conducted by these men demonstrated conclusively that flourides were responsible for the needle burn and death of ponderosa pine in the Spokane area.

By air sampling, atmospheric concentrations of less than 1 part per billion to 351 parts per billion (PPB) of flourine were demonstrated to occur in the area. Highest atmospheric concentrations were correlated with the "center of visible damage," and lower aerial concentrations with lower degrees of damage. Highest concentrations at all sampling sites were also correlated with periods of air inversion, which, in the Spokane area are most numerous during the month of June, when air inversions may occur as frequently as 20 days in the month. Significantly air inversions are most numerous during the period of greatest sensitivity of ponderosa pine; i.e., the period of elongation for current season's needles.

By field studies and spectrographic analysis of a total of more than 5,000 needle samples collected during 18 consecutive months from every section of a 200 square mile area surrounding the center of damage, it was demonstrated that:

1. For needles of comparable age flourine content was inversely correlated with distance from the center of damage; i.e., the

highest flourine contents were found closest to the center and the lowest concentrations were found at the greatest distances from the center.

2. In general at any sampling site within the damage area the flourine concentration was directly correlated with the age of the needles sampled; i. e., the older the needles, the greater the concentration of flourine in the needles.

3. Needles from well outside the area of damage (15-50 miles away) consistently contained but 5 or less parts per million (PPM) of flourine. Occasional samples of dusty needles from such locations contained as much as 10 PPM.

4. In contrast needles collected within one mile of the center of damage contained as much as 620 PPM--which represents a build up in needle tissue of approximately 2,000 times the highest concentration ever recorded in the atmosphere.

   At 1-2 miles the highest concentration in needles was 140 PPM; at 2-3 miles, 130 PPM; 3-4 miles, 80 PPM; 6-7 miles, 40 PPM; 7-8 miles, 35 PPM; 8-9 miles, 25 PPM; 11-12 miles, 8 PPM. Beyond 12 miles concentrations of flourine were comparable with those encountered 25-50 miles from the area of damage.

5. Symptoms (needle burn) are normally associated with concentrations of 25-30 PPM or more; however, on elongating needles collected in June typical tip burn has been observed on needles containing as little as 10 PPM.

6. Injury typically occurs in periodic waves--i.e., as a result of successive periods of air inversion when air movement is either non-existant or at most no more than air drift (air speed less than 1 mile per hour).

7. Topography influences the overall pattern of damage, modifying the theoretical circular pattern.

   The basalt bluffs east and west of the center of damage in Spokane County are responsible for the elliposidal shape of the damage area.

8. Flourine absorption apparently does not occur--or is minimal--when the prevailing winds (from the southwest in this area), or any extensive air movement, occur.

9. Rain is a most effective atmospheric scrubber--removing flourine from the atmosphere. Rain after prolonged dry periods also causes a temporary reduction in the amount of flourine detected in unwashed needle samples by washing off dust present on the surface of the needles. Thus, samples collected after the first fall rains may contain less flourine than comparable samples collected earlier. Within 1-2 months, however, the upward trend with age of needles is resumed.

   Analysis of washed needles confirmed the continual upward trend of flourine content with age.

10. That atmospheric flourine is the factor responsible was demonstrated by reverse fumigation. Scrubbed Spokane air was introduced into one greenhouse; unscrubbed air into a second. Typical symptoms resulted on pines and gladioli exposed to unscrubbed air. No symptoms developed on those exposed to scrubbed air.

11. That flourine was the agent responsible for needle burn in the Spokane area was further confirmed by artificial fumigation of healthy ponderosa pine at a location outside the damage area. ponderosa pine seedlings (and gladioli) fumigated for as little as 24 hours at 5 PPB of flourine developed typical symptoms.

12. That atmospheric flourine was the factor responsible was also indicated by protecting experimental glads and ponderosa pine by spraying them with lime. Lime absorbed the flourine before it could enter the leaf tissue. Its presence in the lime and absence from the tissue (or presence in much reduced amounts) was demonstrated by chemical analysis--and correlated with the absence of burn on lime-sprayed plants. Unprotected plants showed typical burn--and again the severity was correlated inversely with distance of the exposure site from the center of damage.

13. That the atmosphere, not the soil, was the source of flourine was indicated by analysis of needles, twigs and sapwood from

the trunk and roots. Only the needles were ever found to contain more than 10-15 PPM--even in the area of greater damage--indicating that flourine once absorbed by the needles is not translocated and that flourine in the soil is not normally absorbed by plant roots.

14. There are obvious differences in susceptibility within the ecotype of ponderosa pine growing in the Spokane area. In areas of greatest damage all trees have now been killed, but at the time of the study (1949-53) some 5% were still alive and some showed but little visible injury. Similar differences can still be found in areas nearest to the center where some trees are still alive.

15. Similarly there is great difference in susceptibility among tree species.

    Limited evidence indicates that of conifers growing in the Spokane region larch is the most susceptible to flourine injury followed by white pine, ponderosa pine and lodgepole pine in that order. Douglas fir (not present in the area of most severe damage) is fairly tolerant.

    Among broad leafed trees certain Rosaceae--especially stone fruits--Italian prune, almond and apricot--are most susceptible. Other species such as willow and birch, are extremely tolerant. Even though analyses of leaves have revealed concentrations above 1,000 PPM in some samples, no visible injury has been apparent on the latter species.

16. Evidence of reduced growth in the absence of visible burn--i.e., in tolerant species--is conclusive for roses. Thus visible burn is not the only type of damage that results.

17. The center of damage coincides with the location of an aluminum reduction plant.

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APPENDIX I. -- ACTIVE PROJECTS

NEW OR MODIFIED*

(Addresses and affiliations for project leaders are given in membership list at end of these Proceedings).

A. Forest Disease Surveys--General

68-A-1 Forest Disease Survey in British Columbia. (J. H. Ginns). Objective: Determine a) losses from diseases, b) relative importance of the prominent diseases, c) methods for appraisal and detection surveys. (replaces 53-A-3 and 57-A-3).

B. Non-infectious Diseases

68-B-1 Detection of chronic photochemical oxidant injury to conifers by remote sensing. (P. R. Miller, R. V. Bega, and R. Heller).

68-B-2 Physiological impact on ponderosa pine growing under natural conditions of chronic exposure to oxidant air pollution. (P. R. Miller).

68-B-3 Effect of frost damage on growth and form of Douglas fir. (J. H. Ginns).

68-B-4 Effect of air pollution damage to ponderosa pine in Colo. (in collaboration with Colo. State Univ. - J. M. Staley). Objective: To isolate susceptible and resistant pines from their natural environment and to experimentally re-expose them to evaluate, root, shoot, and atmospheric influences as potential causes.

C. Cone, Seed, and Seedling Diseases

68-C-1 The Pathology of Douglas-fir Seed: I. A test of effectiveness of fungicides in preventing fungal deterioration of seed stored in cones. (George Harvey).

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* For complete list see Proceedings of the Fifteenth Western International Forest Disease Work Conference, 1967, Appendix I, pages 82-96.

68-C-2 Nematodes in forest nurseries. (J. R. Sutherland).
Objective: To determine: 1) The kinds and numbers of plant-parasitic nematodes associated with forest nursery seedlings in British Columbia. 2) The importance of nematodes as pathogens and as components in seedling disease complexes (nematode-fungus). 3) The best methods of control.

68-C-3 Seed and Seedling Diseases, especially in nursery; and nursery management as affecting seedling health. (D. Drake).

68-C-4 Occurrence and biology of Rhizina root rot in British Columbia. (J. H. Ginns).

D. Root and Soil Diseases or Relationships

68-D-1 Distribution and losses caused by root rots in British Columbia. (J. H. Ginns).
Objective: Supplement present studies in B. C. through more intensive sampling and development of appraisal methods.

68-D-2 Physiology of root-fungus interactions in the disease condition. (D. Hocking).

E. Foliage Diseases

68-E-1 Effect of Elytrodemia deformans on growth of ponderosa pine. (J. H. Ginns).

68-E-2 Needle diseases of conifers. (J. M. Staley).
Objective: To study the pathogenicity of coniferous foliage fungi in the central Rocky Mountains and the etiology of unexplained conifer foliage diseases.

68-E-3 Critical moisture and temperature relationships governing establishment of Lophodermium ponderosae in vivo and in vitro. (Coop. with Colo. State Univ., N. Oshima - J. Dubin).
Objective: To investigate the effects of temperature and moisture on the dispersal and establishment of Lophodermium ponderosae and to study the behavior of the fungus in culture.

F. Stem Diseases (Malformations, Witches-Brooms, Dwarf Mistletoe, etc.).

55-F-2 Chemical control of dwarf mistletoe of conifers in California. (C. R. Quick).

60-F-1 Studies of dwarf mistletoe in British Columbia. (R. B. Smith).

68-F-1 Silvicultural control of dwarf mistletoe in young lodgepole pine stands. (J. A. Baranyay).

Objective: To obtain guidelines relating to silvicultural management of mistletoe infected pine stands, within this to test the effectiveness of different thinning methods to control of dwarf mistletoe, to study disease intensification and tree growth relationships in treated and untreated stands, and to obtain cost figures for silvicultural control of dwarf mistletoe.

68-F-2 Effects of dwarf mistletoe on growth and mortality in immature ponderosa stands. (F. G. Hawksworth, P. C. Lightle, and T. E. Hinds).

Objective: To determine the effects of dwarf mistletoe on growth and yields in immature ponderosa pine stands in Arizona, New Mexico and Colorado.

68-F-3 Silvicultural control of lodgepole pine dwarf mistletoe. (joint study R-2 and RM Station, J. M. Stewart, F. G. Hawksworth, T. E. Hinds).

Objective: To determine the effectiveness of sanitation in young lodgepole pine stands with various intensities of infection.

68-F-4 Yield tables for mistletoe infected lodgepole pine. (joint study R-2 and RM-Station, J. M. Stewart and F. G. Hawksworth).

Objective: To develop tables for predicting yields in lodgepole pine stands in relation to stand age, site index, density, and intensity of infection.

68-F-5 In vitro culture of Arceuthobium spp. (E. F. Wicker).

Objective: To grow the dwarf mistletoes (Arceuthobium spp.) on artificial media.

68-F-6 Spread and intensification of dwarf mistletoe in young uni-storied stands of western larch, Douglas fir and lodgepole pine with controlled stocking. (E. F. Wicker and

C. D. Leaphart).

Objective: To determine the rates of spread and intensification of dwarf mistletoes in young stands of western larch, Douglas fir and lodgepole pine growing under managed conditions of controlled stocking.

68-F-7 Properties of dwarf mistletoe-infected wood of ponderosa pine. (Donald M. Knutson).

G. Stem Diseases - Stains and Decays

H. Stem Diseases - Rusts and Cankers

65-H-4 Cytology of western gall rust fungi. (R. G. Krebill).

Objective: Evaluation by electron microscopy.

68-H-1 Epidemiology of stalactiform rust of lodgepole pine. (R. G. Krebill).

68-H-2 Nuclei of Jeffrey pine limb rust fungi. (R. G. Krebill and D. L. Nelson).

Objective: To determine behavior of nuclei in aeciospores and their germ tubes of Peridermium filamentosum and Peridermium stalactiforme from Jeffrey pines.

68-H-3 Insect vectors of aspen cankers. (Coop. with Colo. State Univ., T. O. Thatcher - N. G. Hussain).

Objective: To study insects that are suspects in the transmission of Ceratocystis canker of aspen.

68-H-4 Chromatographic analysis of Cronartium ribicola pycnial fluid. (E. F. Wicker).

Objective: To separate and identify the organic compounds of pycnial fluid of C. ribicola.

68-H-5 Translocation of dye in western white pine infected with blister rust. (C. D. Leaphart).

Objective: To trace the pattern of distribution of dye materials through rust infected portions of western white pine stems and branches and to compare these patterns by type and condition of cankers according to class of tree.

68-H-6 Pectic enzymes associated with blister rust. (N. E. Martin).

Objective: To determine the quality and quantity of pectic enzymes involved in the ramification of Cronartium ribicola in western white pine callus tissue and the effects of some indigenous inhibitors of enzyme activity.

I. Wilt and Blight Diseases

J. Defects and Decays of Forest Products

68-J-1 The ecology of infection of hemlock and the true firs by Echinodontium tinctorium. (D. E. Etheridge).

Objective: To define factors of the environment which significantly influence infection of the host by Echinodontium tinctorium.

68-J-2 Taxonomy and cultural characters of wood destroying fungi in western North America. (J. H. Ginns).

Objective: By clarifying the taxonomy of these species, a better understanding of their wood destroying capabilities and relative economic importance should result.

68-J-3 Establishment of threshold concentrations of fungicides for lumber. (J. W. Roff).

Objective: To reduce the deterioration by mould and stain in unseasoned packaged lumber during prolonged storage through improved chemical treatment.

68-J-4 Deterioration of stored pulp chips in outdoor piles. (Roger S. Smith).

Objective: To study the ecology of pulpwood chip piles in relation to fungal activity affecting the wood pulping properties and to indicate the role of important organisms isolated in them.

68-J-5 Role of heartwood microflora in the breakdown of thujaplicin in western red cedar heartwood. (B. J. Van der Kamp).

APPENDIX II. -- TERMINATED PROJECTS

53-A-3 Disease survey in British Columbia (A. C. Molnar and W. G. Ziller). (now included in 68-A-1).

57-A-3 Exotic plantation studies (A. C. Molnar). (now included in 68-A-1).

53-D-8 Root diseases of forest conifers. (W. W. Wagener).

53-E-4 Needle diseases of white pine (W. W. Wagener).

54-E-1 Rhabdocline on Douglas fir. (C. W. Waters).

57-E-1 Elytroderma deformans. (C. W. Waters).

62-E-1 Survey of needle cast diseases in the central Rocky Mountains. (J. M. Staley).

55-F-3 Dwarf mistletoe of western larch and lodgepole pine. (C. W. Waters).

57-F-1 Dwarf mistletoe of western larch, lodgepole pine and Douglas fir. (C. W. Waters).

62-F-4 Cyto-taxonomic studies of Arceuthobium campylopodum and A. vaginatum. (Del Wiens).

62-F-6 Effects of dwarf mistletoe on yields of young lodgepole pine. (F. G. Hawksworth).

57-G-4 Studies on Idaho wood-rotting fungi. (R. L. Gilbertson).

62-G-4 Decay in advanced alpine fir regeneration in British Columbia. II. In the Kamloops District. (R. B. Smith and H. M. Craig).

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-10 Analysis of physical and ecological site factors contributing to high rust hazard. (C. R. Quick).

55-H-2 Tests of fungicides to inhibit blister rust development on the leaves of ribes bushes. (C. R. Quick).

58-H-2 Western tree rusts of Coleosporioides complex. (W. W. Wagener).

65-J-2 The use of gas chromatographic methods for carbon dioxide detection in the respiration of fungi attacking wood. (R. S. Smith).

66-J-2 Interaction of fungi and chemical preventives- Dihydroquercetin. (A. J. Cserjesi).

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 of pathogenicity tests on selected clones of poplar, including introduced varieties. (J. E. Bier).

64-K-3 The time required for Tuberculina maxima to inactivate blister rust infections on western white pine. (J. W. Kimmey).

65-K-5 Survey of naturally inactivated lethal-type blister rust cankers on young western white pine in the Inland Empire. (J. W. Kimmey).

67-K-9 In-season tree failure on California recreational areas. (L. A. Paine).

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APPENDIX V. -- MINUTES OF BUSINESS MEETING

The business meeting was called to order by Chairman Stuart Andrews at 2030 hours, October 31, 1968.

I. Secretary - Treasurer's Report.

Minutes of the 15th meeting were adopted as they appeared in the Proceedings.

Financial statement

	Credit	Debit
Balance, 15th Conference	197.52	
Registration, 16th Conference	476.50	
North Shore Motor Hotel		166.35
Bus expenses		200.00
Coffee (P.R.E.F.)		4.26
To G. W. Wallis (binding proceedings)		13.19
	665.02	383.80
Balance to incoming Secretary-Treasurer, R. L. Gilbertson (at Wells Fargo Bank, Berkeley)	$281.22	

II. Committee Reports

Reports of the Dwarf mistletoe, Recreation Hazard, Control, and Interim Program Committees were discussed and appear as Appendix VI.

III. Old and New Business

1. Honorary Life Membership
The following were added to the list of Honorary Life Members, Dr. T. W. Childs, Dr. J. R. Hansborough, and Mr. C. R. Quick. Dr. R. W. Davidson was restored to the list of Honorary Life Members in accordance with a resolution passed at the 15th Conference. The Secretary-Treasurer was instructed to so inform these Honorary Life Members.

2. Participation by Mexican Members
The desirability of fostering meaningful contact with forest pathologists in Mexico was emphasized since forest diseases are not restricted by international boundaries. It was suggested that the incoming chairman make particular effort to determine how the participation of Mexican members can be assured. The attention of the meeting was also drawn to the existence of two different lists of forest pathologists in South America which did not coincide. This matter was also considered worthy of attention of the incoming executive.

3. 1969 Meeting
After discussion of the suitability of various locations for the next meeting, including Victoria, B. C., Hawaii and Yellowstone National Park, the majority voted for Olympia, Washington proposed by K. W. Russell and eloquently supported by K. R. Shea.

4. Election of Officers
Following nominations from the floor, the following were elected for 1969.

Chairman -- G. W. Wallis

Secretary-Treasurer -- R. L. Gilbertson

5. Commendations
Chairman Andrews expressed the thanks of the meeting for a job well done by Don Leaphart and the local Arrangements Committee, and Jim Stewart and the Program Committee.

6. The meeting adjourned at 2145 hours.

STATUS AND NEEDS OF RESEARCH ON DWARF MISTLETOES COMMITTEE

F. G. Hawksworth, Chairman

HIGHLIGHTS OF 1968 ACTIVITIES

I. TAXONOMY, HOSTS AND DISTRIBUTION

a. Dwarf mistletoe, Arceuthobium campylopodum f. cyanocarpum, was found on Brewer spruce in the Siskiyou National Forest in southwestern Oregon. The mistletoe was common on associated western white pine. (Bynum, U.S.F.S., Medford).

b. A taxonomic monograph of the genus Arceuthobium is nearing completion and a final draft should be ready early this winter. Most of necessary field work has been finished and final analyses are underway. Dr. Wiens has studied the European and Asian species of Arceuthobium this summer so the monograph will treat the entire genus, not just the North American taxa as was originally planned. (Hawksworth, U.S.F.S., Fort Collins; and Wiens, Univ. of Utah, Salt Lake City).

c. Lodgepole pine dwarf mistletoe, Arceuthobium americanum, is reported in Canada for the first time on Scots pine, Pinus sylvestris, and for only the second time in North America. (Plant Dis. Rep. 52: 409-410, 1968). It was discovered in three 26-year-old plantations near Seebe, Alberta, and was associated with infection on adjacent lodgepole pine and white spruce. (Powell, Calgary).

II. PHYSIOLOGY AND ANATOMY (No Reports)

III. LIFE CYCLE STUDIES

a. Buildup of dwarf mistletoe in red fir inoculated in 1957 continues to be quite rapid. A total of 234 infections were located in 1968 on the five test trees. Interestingly enough all infections are within

8 feet of the ground. It was calculated that the average vertical spread of the parasite for the 10-year period was only 4 feet, whereas the average height growth of the test trees over the same period was about 13 feet. (Scharpf, U.S.F.S., Berkeley; and Parmeter, Univ. Calif., Berkeley).

b. Studies on population dynamics of dwarf mistletoe on true firs in California were continued this year to include A. campylopodum f. abietinum on white fir. The data have not been thoroughly analyzed yet, but preliminary results suggest that the dwarf mistletoe situation in white firs is similar to that which occurs in red fir stands. Tree height appears to be the most significant factor relating to dwarf mistletoe infection. (Scharpf, U.S.F.S., Berkeley).

c. To obtain basic information on the life cycle of the pinyon dwarf mistletoe (Arceuthobium campylopodum f. divaricatum), a series of inoculations was established on Pinus edulis in the Sandia Mountains, of New Mexico. (Lightle, U.S.F.S., Albuquerque).

d. Tentative results from a series of about 6,000 Arceuthobium americanum seeds planted over a 6-year period show that shoots first appeared from the second to seventh year after planting. Most infections (70%) first produced shoots in the third or fourth year. Abundant fruiting began in the sixth year for all years' inoculations. The approximately 400 infections that have produced flowers to date show a sex ratio that is not significantly different from 50:50. (Hawksworth, U.S.F.S., Fort Collins).

IV. HOST-PARASITE RELATIONS

a. Dwarf mistletoe was successfully transmitted in spring under field conditions to noninfected ponderosa pines by patch grafting. About two out of three grafts that were made took. All grafts that took succeeded in transmitting the parasite. Infections with shoots and flowers developed 3 years after grafting. (Scharpf and Bynum, U.S.F.S., Berkeley).

b. Spread of dwarf mistletoe (Arceuthobium americanum)was measured from uniform, straight margins of residual stands and from single residual trees into uniformly aged (27 years) stands of lodgepole pine in a forest

in southern Alberta. Residual trees and stands, 60-90 years age, were arbitrarily selected. Minimum dimensions for stands were 200 ft. by 200 ft. square, and spread was measured not closer than 100 ft. from any corner of a residual stand. Eleven measurements of spread were obtained from nine residual stands; and 53 single residual trees. Average distance of spread from residual stands was 27.9 ft. (range 14 to 52 ft.) which was comparable to distance of spread measured by Hawksworth and Graham (J. Forestry 61: 579-591, 1963). Average spread from single residual trees was 45.1 ft. (range 20 to 74 ft.). Although the infection sources were not selected randomly, the data were analyzed by a "t" test. Distance of spread from the single residual trees was significantly greater, at a probability of 0.01, than spread from the stands. These observations indicate that control measures to prevent spread of dwarf mistletoe into young stands of lodgepole pine should first be applied to single residual trees. (Muir, Calgary).

c. Extent of infection by dwarf mistletoe (A. americanum) was surveyed in a young (27 years of age) forest of lodgepole pine in southern Alberta. On 18 transects, one-quarter chain wide by 40 to 60 ch. long, 13.2 ac. of young forest was examined. Average proportions of infected area of young stands was 1.8%. An additional 0.8% of the total area of young stands, located less than 30 ft. from infected residual trees, showed no signs of infection. Apparently spread of dwarf mistletoe into a large proportion of young stands exposed to infection, had been delayed considerably by unknown factors. Of the total area of young infected stands on the transects (23 separate infection centers), 3% (4 infection centers) was located 130 ft. or more from any infected residual tree. Apparently these four centers had been established quite recently since only a few small dwarf mistletoe infections were present in each center. Apparently spread of dwarf mistletoe in young stands also occurs by other means in addition to local dispersal of seed. (Muir, Calgary).

V. EFFECTS ON HOSTS

a. Field work was completed on a joint study (Rocky Mountain Region and Rocky Mountain Forest and Range Experiment Station) to predict yields in mistletoe-infested lodgepole pine stands in Colorado and

Wyoming. The data from the 42 plots on various site classes, age classes, and degrees of mistletoe will be analyzed this winter. (Hawksworth, U.S.F.S., Fort Collins).

b. Preliminary studies were made on the effects of Arceuthobium americanum on wood properties of lodgepole pine. Infected versus non-infected wood from the same cross sections was compared. There were no differences between moisture content in infected and healthy wood. However, infected wood had a higher specific gravity and significantly shorter tracheids than non-infected wood. (Smythe, Colo. State Univ., Fort Collins).

c. Growth impact study on western hemlock is yet in progress as originally reported at the Sante Fe meeting. (Russell, Dep. Nat. Resources, Olympia).

d. A new study has been started to determine the properties of dwarf mistletoe-infected ponderosa pine wood. Comparisons of infected vs. uninfected wood will be made for moisture content, specific gravity, and toughness. (Knutson, U.S.F.S., Corvallis).

e. Synthesis of data from the stem analysis of 30 western hemlock averaging 110 years of age and varying in intensity of hemlock dwarf mistletoe infection has been completed. Considerable growth retardation was indicated in severely infected trees despite their earlier establishment and greater height during a large portion of their lives, than lightly and moderately infected trees. From 1955 to 1962, lightly infected trees had 41% greater volume growth and 84% greater height growth than severely infected trees. Volume loss became evident in 1945, and for dominant and codominant trees was nearly 60 cu. ft. per acre per year by 1960. Records of the number and size of dwarf mistletoe infections on each tree enabled evaluation of assessment procedure and resulted in the recommendation of a rating system utilizing only the middle third of the tree. (Smith, Victoria).

VI. ECOLOGY

a. Mistletoe-infected lodgepole pines were transplanted into the mistletoe-free zone near the upper limits of the lodgepole pine type in Colorado in an attempt to learn the reasons for the zone. Preliminary

observations made after the first summer suggest that fruits did not mature in the mistletoe-free zone. (Hawksworth, U.S.F.S., Fort Collins, and Laut, Colo. State Univ., Fort Collins).

b. The results of studies near Sicamous, B. C., concerning relationships between forest succession and the distribution of Douglas-fir dwarf mistletoe are presented in Panel III of these proceedings. (Smith, Victoria).

c. The influence of wind speed, wind direction, temperature, humidity, rainfall and sunshine on the time and pattern of hemlock dwarf mistletoe seed dispersal is being investigated for a second season. Daytime (0745 - 1445 PST) dispersal has been 3-5 times the rate of nightime dispersal. (Smith, Victoria).

VII. CONTROL - CHEMICAL

a. Paraquat and another chemical that appears to be an effective desiccant of mistletoe shoots are being tested at Boggs Mountain State Forest and Eldorado National Forest in California. Both materials have been in test too short a time to evaluate their effectiveness. (Thomas, Chevron Chem. Co., Richmond, Calif.).

b. The California Region of the Forest Service continued the chemical testing project first reported to the committee in 1967. Readings were taken of all the 1966 tests, and one new test was established. The two-year results have not been analyzed, but in general they are encouraging. In 1968 the Region extended the testing to the use of 2, 4,-5TP (Dow Duron) in direct application. This test series consists of a late summer application of 2,4, 5-TP at 0.3% in stove oil, 2, 4, 5-TP at 2.5% in a water-oil emulsion, and 2, 4-DA at 0.1% in stove oil, directly to dwarf mistletoe plants. The 2,4-DA is included for comparison with earlier tests. The 2,4, 5-TP was chosen because it is commercially available and showed up well in Quick's tests. (The 2,4,5-TB is not commercially available.) The testing is being done on the Klamath National Forest (ponderosa pine), and on the San Bernardino National Forest (Jeffrey pine). Eighty trees, including controls, constitute the test at each location. (MacGregor, U.S.F.S., San Francisco).

c. Examination of tests made in Colorado in 1965 and 1966 show that all the following were ineffective:

1. 606 infections of A. americanum sprayed with 0.25 to 4.0% 2,4,5-TB in August 1965;
2. 33 infected lodgepole pines sprayed with 1.0 to 4.0% 2,4,5-TB in June 1966;
3. 15 infected lodgepole pines injected with Bidrin in June 1966;
4. 25 infected lodgepole pines injected with Di-Syston in October 1965;
5. 25 infected lodgepole pines injected with Meta-Systox in June 1966;
6. 22 ponderosa pines infected by A. vaginatum injected with Meta-Systox in June 1966; and
7. 25 ponderosa pines infected by A. vaginatum injected with Di-Syston in October 1965.

(Hinds and Hawksworth, U.S.F.S., Fort Collins).

d. The following are reports of several chemical control tests in California:

1. Examination of tests started in 1959 with 245-TA (Weedone LV-4) at 0.2% on dwarf mistletoe of Jeffrey pine showed no shoots in 1966, although the endophytic system apparently was still viable.
2. Tests with 245-TP started in 1961 on sugar pine dwarf mistletoe showed good control in 1967, but 10 to 25% of the trees--largely trees under 10 feet in height--were killed.
3. Comparative effectiveness tests with diesel oils vs. water-oil emulsion as spray carrier for 245-TB on ponderosa pine dwarf mistletoe were begun in 1963. Encouraging results after 4 years suggested little difference on bole infections, but diesel oil seemed slightly more effective for limb infections.
4. 1965 tests with Tidewater Oil Co. aromatic (benzenering) fractions from petroleum suggest that some were promising (e.g., Aromatic Oil 400-W) while Avon Annalos #11, a "weed oil", caused much tree mortality.
5. The importance of choice of carriers, specifically of petroleum oil carriers, is believed inadequately explored. (Quick, PSW - Berkeley)

VIII. CONTROL - BIOLOGICAL

a. Extensive feeding by British Columbia red squirrel (Tamiasciurus hudsonicus columbiensis Howell) was observed on the living bark tissues of dwarf mistletoe (Arceuthobium americanum Nutt. ex Engelm.) infected lodgepole pine branches near Lake Louise and Jasper in Alberta and north of Clinton in British Columbia during the spring of 1968. Dwarf mistletoe infected small branches about 0.25 inch diameter were cut by the squirrels and carried either to caches or to trees with dense crown where the bark of the swellings were gnawed. Feeding was restricted to the bark affected by the endophytic system of the parasite. (Baranyay, Calgary)

b. Incidence of Colletotrichum gloeosporioides and its possible effects on intensification of dwarf mistletoe (A. americanum) were studied in 1967 in two immature lodgepole pine stands in Alberta. In one stand 75% of the dwarf mistletoe infections (300 total examined) had at least one shoot infected by C. gloeosporioides, and 45% of the total shoots (5600) had at least one lesion of C. gloeosporioides. Eight percent of the dwarf mistletoe berries (1380) were infected or were located distally to lesions of the fungus. In the other stand 35% of the infections (680) had one or more shoots infected, and 7% of the shoots (12,200) were infected. Seven percent of the berries (1500) were infected. Effects of the fungus on intensification of dwarf mistletoe were examined by determining the ages of the selected infections from each stand. The infections were transversely sectioned, and their ages estimated from the depth of sinkers in each section. By plotting the number of infections per infection age, it was evident that the number of infections established per year in each stand had increased, on the average, at a logarithmic rate during the preceding 8- to 10-year period. It was assumed that the fungus was present in the stands during this period, which seemed reasonable in view of past collections of the fungus in nearby areas. In one stand the logarithmic rate of increase of numbers of infections was not significantly different than rates previously observed in stands where the fungus was absent; in the other stand the logarithmic rate was approximately 66% of the rates previously observed, and was significantly less (at a probability of 0.01). Apparently the fungus also increased

the mortality of dwarf mistletoe infections in both stands. Proportions of dead infections in the two stands were 9 and 13% as compared with an average mortality of 2 to 3% in four stands previously sampled where the fungus was absent. (Muir, Calgary).

c. Septogloeum gillii was found on Arceuthobium americanum in one area in the Medicine Bow National Forest in Southern Wyoming. This is apparently the first record of the fungus from Wyoming. (Hawksworth, U.S.F.S., Fort Collins).

d. Several pathologists have previously noted the association of comandra rust and Arceuthobium americanum in lodgepole pine. In the Routt and Roosevelt National Forests, Colorado, areas have been found in which nearly 100% of the rust infections are associated with dwarf mistletoe. This association is being investigated by the Native Rust project at Logan, Utah. (Krebill, U.S.F.S., Logan; and Hawksworth, U.S.F.S., Fort Collins).

e. Insect damage to shoots of Arceuthobium campylopodum f. laricis was observed rather frequently in the Sherman Creek drainage of the Colville National Forest during the summer of 1968. In some infections the damage was rather severe with almost all the shoots being destroyed. Larvae of at least three insect species and possibly more are involved. Callophrus spinetorum (Hew.) has been identified. We are attempting identification and rearing of the others. (Wicker, U.S.F.S., Moscow).

f. The fungus Wallrothiella arceuthobii (Pk.) Sacc. is very common on A. americanum and A. douglasii in the Sherman Creek drainage of the Colville National Forest. Infection itensity in this area during 1967 and 1968 has been so high as to render the area useless for seed collections of these two species of dwarf mistletoes (Wicker, U.S.F.S., Moscow).

IX. CONTROL - SILVICULTURAL

a. A total of 28 half-acre sample plots were established in a cooperative study between the Rocky Mountain Region, Denver; Rocky Mountain Experiment Station, Ft. Collins, Colorado; British Columbia Region, Victoria; and Alberta-Territories Region, to study the possibility of dwarf mistletoe control by silvicultural means in

young lodgepole pine stands. Our experimental designs is similar to that used in Colorado so data from all regions will be comparable. The plots were established in various age classes exhibiting various rates of dwarf mistletoe infection. One set of plots contains an infected control untreated, healthy control untreated, healthy thinned, infected thinned and dwarf mistletoe eradicated plot. On the infected thinned plots infections were pruned where it was necessary to maintain adequate stocking. Fifteen plots are in Alberta and 8 in the interior of B. C. (near Clinton). Re-treatment of plots are planned in every fourth year. (Baranyay, Calgary).

b. A second cleaning was made on some of the Colorado plots established in the cooperative study mentioned in "a" above to control lodgepole pine dwarf mistletoe in young stands. Several plots in 20-year-old stands first treated in 1965 were re-treated in 1962. A 3-year period between cleaning was judged to be the optimum time between cleanings in this area. The number of trees visibly infected in 1968 was about 50% of the number cut in 1965 on each plot. This percentage increase in the proportion of trees visibly infected since 1965 was apparently not related to the amount of infection originally present on the plots in 1965 (i.e., plots with 4% infection in 1965 had an additional 2% of the trees infected in 1968 and those with 30% infection in 1965 had an additional 15% of the trees infected in 1968). (Hawksworth, U.S.F.S., Cort Collins).

c. Suggestions for possible approaches to silvicultural control of dwarf mistletoe in understory of regenerated red fir stands in California are forthcoming. Guidelines will be presented based on the knowledge that tree height is important in infection by the parasite. (Scharpf U.S.F.S., Berkeley).

d. The Department of Natural Resources is initiating a dwarf mistletoe control project in ponderosa pine and Douglas-fir on approximately 800 acres in eastern Washington. This is a cooperative project with the U.S. Forest Service. (Russell, Dep. Nat. Resources, Olympia).

X. SURVEYS

a. Films obtained during aerial photography of dwarf mistletoe infected

lodgepole pine stands (reported in the 14th Proceedings) were evaluated and the following conclusions were arrived at:

1. Black and white aerial photography failed to illustrate adequate shade differences between healthy and infected patches of trees. This failure could be related to:

(1) The lack of anatomical changes in the needles of the infected lodgepole pine. The spongy mesophyll tissue of coniferous needles is not as well developed as in hardwood leaves and may not react to parasitism in the same manner, or

(2) dwarf mistletoe may not affect the water economy of the host to such an extent as to cause anatomical changes in the foliage.

2. High dwarf mistletoe hazard areas can be detected on colour aerial photographs by stand structure anomalies. Ground surveys should be concentrated in these areas. For this purpose the 1" to 660' (1:7,920) scale is more suitable than smaller scales.

3. Large scale 1" to 200' Ektachrome photography is suitable to detect heavily infected trees with dying, discoloured branches and witches' brooms. It was impossible to separate trees without foliage discolouration within various infection classes. Oblique photography gave better results than vertical.

4. The evaluation of Ektachrome Infrared film was impossible due to underexposure. This is the most suitable film to detect visible colour variations, consequently the most promising for dwarf mistletoe detection. Another experiment with this film is anticipated in 1969. (Baranyay, Calgary).

b. Attempts to detect dwarf mistletoe in ponderosa pine from a fixed-wing aircraft were made on the Deschutes National Forest, Oregon. Infected stands were flown visually and also photographed with Ektachrome and infra-red film. Preliminary analyses suggest that infected stands could not be successfully detected visually. Analyses of the photographs are now underway. (Orr and Wear, U.S.F.S., Portland).

c. In order to determine the type of distribution patterns of young dwarf mistletoe-infected lodgepole pine, 3 infected stands in northern Colorado were mapped. Computer analyses will be made to define the

type of distribution and to determine the best sampling method for such stands. (Kovner and Morris, U.S.F.S., Fort Collins).

d. A survey of western hemlock clearcuts will be conducted to determine the extent of dwarf mistletoe control on older clearcuts. Clearcuts with severe infections will be given priority for immediate control measures. (Russell, Dep. Nat. Resources, Olympia).

XI. STATEMENTS OF PH.D. PROJECTS ON MISTLETOES

a. Richard Hunt, Univ. of California, Berkeley

In general I am working on pre-penetration aspects of dwarf mistletoe on the following three Arceuthobium hosts: red fir, white fir and ponderosa pine. At present I am working on damping-off of the Arceuthobium seeds from the point of view of relating the dwarf mistletoe seed to its host microfloral communities with distant hopes of biological control manipulation. (Advisor, R. J. Parameter).

b. Leonard S. Felix, Univ. of California, Berkeley

The true mistletoe Phoradendron bolleanum subspecies pauciflorum on fir (Abies concolor) in the Sierras of California is a neglected parasite. In many areas this pathogen probably causes more damage than its more publicized cousin Arceuthobium campylopodum f. abietinum.

My work encompasses the biology of the true mistletoe with emphasis on the physiological and anatomical relationships of the host and pathogen. The study includes the secondary invasion of infected white fir by various bark beetles of the genus Scolytus. (Advisor, J. R. Parmeter).

c. John G. Laut, Colo. State Univ., Fort Collins

Within the boundaries of the Manitoba-Saskatchewan Region of the Canada Department of Fisheries and Forestry are located the northern limits of both A. americanum (on jack pine) and A. pusillum (on white and black spruces), the western limit of A. pusillum and the eastern limit of A. americanum. Neither species of dwarf mistletoe approaches the geographic limit of its respective host. As is the case with most dwarf mistletoes, within their geographic range there exists areas from which the parasites are excluded (i.e. patchy-distribution). This project has been set up, under the aegis of the Canada Department of Fisheries and Forestry with the following objectives:

1. To describe the effects of various environments on the biology of A. americanum and A. pusillum.

2. To explain why these species of Arceuthobium are naturally excluded from certain environments as evidenced by their distribution patterns.

3. To incorporate natural exclusion factors into dwarf mistletoe control recommendations for Manitoba and Saskatchewan. (Advisor, F. G. Hawksworth).

d. Mary Ann Sall, Oregon State Univ., Corvallis
Epidemiology of Arceuthobium campylopodum on ponderosa pine (Advisor; L. F. Roth).

COMMITTEE ON FOREST DISEASE RECREATION HAZARD

G. W. Wallis, H. R. Offord, and L. A. Paine, Chairman

REVIEW AND 1968 DEVELOPMENTS

I. TREE FAILURE REPORT PROGRAM

Accelerated research on the problems of defect detection, hazard evaluation, and control of hazard on recreation sites has been in progress since 1966. As an essential part of the program, cooperating agencies provide records (PSW-4600-3) of tree failures on recreation sites--including information on predisposing conditions such as rot, and contributing factors such as wind. These data provide figures on losses, classes of failure, and the factors involved in failure for each species.

The subsequent analyses at the Pacific Southwest Forest and Range Experiment Station are the basis for guidelines for inspection and control, and will point out those problems (based on frequency and losses) which require detailed investigation. The failure report program is expected to continue for another 4 years, with a subsequent extension if necessary.

In addition, a limited amount of control data is now available for analysis. Compared with the figures on uncontrolled failures, the data

will provide a measurement of practical success in detection by class of failure, and a basis for recommending changes in emphasis during hazard inspections.

II. INCREASE IN REPORTING AREA

Until this year, only Federal agencies in California were participating in the collection of data on failures of hazardous trees. This restriction severely limited both the rate of collection of data and the range of species and conditions. Beginning in 1968, the reporting area has been enlarged to include Alaska, Hawaii, and the States west of the Mississippi River. All Federal agencies which manage forested recreation sites within this area are cooperating in the program. These agencies include the Forest Service, National Park Service, U.S. Army Corps of Engineers, Bureau of Land Management, Bureau of Indian Affairs, and isolated units of the Bureau of Sport Fisheries and Wildlife. In addition, some West Coast State and public utility organizations are involved.

III. RECENT AND CURRENT WORK

Two recent papers (listed in Appendix IV - Publications) discuss the evaluation of losses and protection costs as a basis for establishing local control priorities and budgets.

In addition to the analysis of practical success in defect detection, mentioned above, we are working on the relative importance of specific predisposing conditions as indices to potential failure. Relating the predisposing conditions only to the class of failure, however, would result in unnecessary attention to unimportant defect. Consequently, recommendations are now made with a view to cost-benefit relations, including the average losses caused by each class of failure. The resulting guidelines are flexible enough either to permit maximum utilization of a limited hazard control program or to provide for more thorough coverage in an "unlimited" program.

IV. NEEDED MANAGEMENT DECISION

One of our basic needs is management's definition of acceptable

loss on recreation sites--based on either failures, or injuries and property damage. No broad hazard control program can be 100 percent successful unless all trees over 5 feet high are eliminated. But practical and acceptable levels of control have not been defined. Until those goals have been specified, guidelines can only be tied to utilization of a limited budget, rather than to achievement of acceptable risk levels. (Paine, U.S.D.A. Forest Service, Berkeley).

FOREST DISEASE CONTROL COMMITTEE

H. Toko, L. C. Weir, H. H. Bynum, J. L. Stewart,
A. C. Tegethoff, and K. W. Russell, Chairman

HIGHLIGHTS OF 1963-68 CONTROL STUDIES

1. CHEMICAL

a. Cooperative Sugar Pine Secondary Screening Test

In September 1966, a secondary screening test for the control of white pine blister rust on sugar pine was installed under a cooperative agreement involving Regions Five and Six and the Pacific Northwest and Pacific Southwest Forest and Range Experiment Stations. Chemicals involved in the test of direct canker application included Actidione BR (300ppm), Biphenyl, Cyprex, Dowicide 1, and Mertax. Insufficient time has elapsed in which to draw any final conclusions as to the effectiveness of the chemicals. (Bynum, Region 6 U.S.F.S.)

b. Test for Chemical Control of Dothistroma pini on Shore Pine (Pinus contorta)

Chemicals were applied in the spring of 1965 to test for prevention of Dothistroma pini infection in a severely diseased Christmas tree plantation of shore pine on the Oregon Coast. Chemicals tested included Bordeaux mixture (4-4-50), Phytoactin L-318 (300 ppm) in stove oil, cycloheximide acetate (100 ppm), and cycloheximide thiosemicarbazone (100 ppm). Phytoactin L-318 had no noticeable effect on the occurrence of the fungus in comparison to untreated

control trees. The cycloheximides prevented infection somewhat, but these antibiotics produced excessive phytotoxicity at the concentration used. Three foliage drenches with Bordeaux mixture during the one month period of greatest growth reduced the incidence of infection noticeably, but the amount of infection was slightly greater than tolerable for Christmas tree production. The infection level would likely be reduced more by a larger number of applications. (Thompson, Region 5 U.S.F.S.)

c. Test for Chemical Control of Rhabdocline pseudotsugae on Douglas-fir Antibiotics were applied to Douglas-fir trees in a Christmas tree plantation in June 1964 to test for prevention of the Douglas-fir needle cast (Rhabdocline pseudotsugae). Spray formulations contained as their primary ingredients the following antibiotics: Phytoactin L-318, Phytoactin L-440, cycloheximide acetate, and cycloheximide acetate (200 ppm) and (50 ppm) in water reduced infection encouragingly as compared to non-treated controls. However, this promising antibiotic was not further tested because the producing company ceased making it. (Thompson, Region 6 U.S.F.S.)

d. Chemical Tests for the Control of Western Gall Rust on Monterey Pine A series of chemical tests for the control of western gall rust was begun in 1962 in a Monterey pine plantation on the Oregon Coast. Phytoactin, Actidione, dimethyl sulfoxide, and stove oil in various formulations have been the substances primarily tested. Preliminary results indicate that formulations containing stove oil have a relatively toxic effect on galls that have been thoroughly scarified before direct spray application. Gall mortality may very likely be due to killing of host tissue rather than fungal mycelium. The efficacy of such control is still in doubt due primarily to the possibility that the area of dead galls may serve as an infection court for other opportunistic fungi. (Thompson, Region 6 U.S.F.S.)

e. A study was started in an attempt to find a chemical control for Lophodermella cerina on ponderosa pine. The study will be completed in the spring of 1969. (Weiss, Region 3 U.S.F.S.)

f. Tests of cycloheximide and phytoactin for control of blister rust on western white pine. (Leaphart, Wicker, and Kimmey--INT Station). Evaluation of two antibiotics, cycloheximide and phytoactin, to control

blister rust was concluded in 1966 following tests started in 1963 on 1,038 trees subjected to either aerial spray or basal stem treatments. This evaluation was reported in the following publication.

Leaphart, Charles D., and Ed. F. Wicker. 1968. The ineffectiveness of cycloheximide and phytoactin as chemical controls of the blister rust disease. Plant Disease Reporter. 52(1): 6-10.

Abstract: The antibiotic phytoactin was not an effective control for the blister rust disease of western white pine. When applied in either aerial or basal stem treatments, the results were not significantly different from those of the treatment controls. The cycloheximide basal stem treatment, having 26 percent inactive cankers four growing seasons after treatment, was significantly different from treatment controls, but was also considered to be an ineffective control of the disease for reasons given. Tuberculina maxima, a rust canker parasite, is definitely implicated in reduction of activity of cankers in the treatment controls.

g. Control tests on Rhabdocline was Phytoactin - Started in 1964, completed 1966. Information contained in:

Weir, L. C., and A. L. S. Johnson. 1967. Use of Phytoactin in the treatment of Rhabdocline needlecast disease of Douglas-fir. Phytoprotection 48(2): 74-77.

h. Control tests on Rhabdocline pseudotsugae with Meta-Systox-R. Abstract - Foliar and stem sprays of Meta-Systox-R produced a desirable trend in decreasing infection levels. Concentrations used were too low to reduce infection to commerically acceptable levels. (Weir-Victoria)

i. Control tests on Atropellis piniphila using Actidione - Preliminary tests were carried out to ascertain the existence of material translocation in lodgepole pine. Evidence indicates movement within one day and persistence for the length of the sample period of two weeks. (Weir-Victoria)

j. Fomes annosus - A series of stump treatments have been carried out to test the effectiveness of materials in preventing colonization by F. annosus. In those tests that have been completed, borax solution is the most effective,with urea having little or no preventative effect. (Weir-Victoria)

k. Continuation of stump treatments against F. annosus infection to determine variation in time of year of treatment. (Weir - Victoria)

l. Treatment of stumps innoculated with spores of F. annosus at varying periods after inoculation to determine if a period of time may elapse between felling and treatment. (Weir-Victoria)

m. Controlling Pythium root rot in nursery grown Douglas-fir
In September 1966, several fumigants: Vorlex, Telone, Pathofume B, Brozone and P.B.C. One of the nursery blocks that was treated had abnormally high populations of Pythium spp. At this writing visual evidence of control of all treatments is good. Root growth measurements made during the fall of 1968 will be done to evaluate the tests. (Russell, D.N.R., Olympia, Washington)

n. Fomes annosus control.
Four chemical formulations are being tested for control of Fomes annosus stump infections in precommercial sized western hemlock. Monthly stump applications of urea and borax (two concentrations and one dry application) are the chemicals being used. The study, launched in June 1968, will run for fifteen months. Three plots each were established in Washington and Oregon. The study is being conducted jointly by Region 6 U.S.F.S., the University of Washington College of Forestry and Washington D.N.R. (Stewart, Driver, Russell, Olympia, Washington)

II. BIOLOGICAL

a. Breeding of Blister Rust Resistant Western White and Sugar Pine
A Joint Forest Service-Bureau of Land Management project for the breeding of rust-resistant western white and sugar pines has been under way in Washington and Oregon since 1957. Early results have been encouraging, and the project has expanded accordingly. Expectations include mass production of F_1 seed in five to six years. (Stewart, Thompson)

b. Natural Inactivation of Blister Rust Cankers on Western White Pine
A study on natural inactivation of blister rust cankers on western white pine was initiated in 1966. Cankers are being observed on 49 plots in six national forests in the Inland Empire. Currently, 727 lethal cankers are under observation and new cankers found during any

examination are added to the base. Observation of these cankers showed that 16 percent, 20 percent, and 23 percent were inactive for the years 1966, 1967, and 1968, respectively.

Preliminary analysis of the 1966 and 1967 data revealed a positive correlation between canker age and inactivation. Examination of the data also shows a large variation in inactivation between plots. More detailed analyses of the data will be made and may reveal some possible causes of inactivation. (Hungerford, INT Station)

c. Fomes annosus

Field work has been carried out to determine which fungi inhabit stump tops following thinnings in Douglas-fir and western hemlock. These tests were carried out on stumps treated with chemicals as well as untreated stumps. The associated laboratory study will determine antagonism of fungi to F. annosus with a view toward biological control. (Weir-Victoria)

III. SILVICULTURAL

a. Poria weirii

Initial phases in a study to determine the effectiveness of clearing stumps and big roots from pockets of P. weirii infection have been completed. An eight-acre block of infected Douglas-fir and lodgepole pine has been logged and one half of the area cleared. Planting of susceptible species has been carried out and associated studies like changes in soil microflora have been initiated. (Weir - Victoria)

b. The effect of thinning lodgepole pine to various stand densities on the spread of Atropellis piniphila, Peridermium stalactiforme and Peridermium harknessii. (Weir-Victoria)

c. Test of the Effect of Thinning on the Spread and Intensification Armillaria in Ponderosa Pine

A study was begun in 1966 to determine the effect of thinning on the spread and intensification of Armillaria mellea in a heavily infected stand of ponderosa pine poles and saplings. Insufficient time has elapsed in which to draw conclusions from the test. Study plots will be kept under surveillance for a number of years to best ascertain the effect of the thinning on the spread of the parasite. (Thompson, Stewart, Region 6 U.S.F.S.)

These items were discussed at Coeur d'Alene:

1. Informal meetings could be arranged between committee members to review localized new disease control methods on occasion. Any member could request such a meeting.
2. Arrange for a consensus of the group on new control activities. Proposals could be sent to committee members for review. This would avoid duplication West-Wide.
3. New members added at 1968 meeting:

Jack Thompson	Neil McGregor
Mel Weiss	Dave Graham
Dennis Hart	Reid Miller
Oscar Dooling	Don Brown

INTERIM PROGRAM CHAIRMAN'S REPORT

O. J. Dooling

Panels or workshops to discuss the following topics were suggested.

1. Chemical, biological and silvicultural control of forest disease.
2. History of forest pathology in the west. The panel should include emeritus and long term members whose experience reaches back to the early years. (e.g. Childs, Kimmey, Miller, Offord, Wagener)
3. Disease impact surveys.
4. Cost-benefit ratio. A panel to include economists and others to discuss ways, means and significance of ratios.
5. Diseases of artificially reforested areas in the west.
6. Problems of concern to the industrial forest manager. A panel of industrial representatives to introduce and discuss industrial management and research problems.
7. Is there any threat from new disease introductions?
8. Nursery diseases.

9. Ecology of organisms associated with wood stains and decay (Dr. R. F. Scharpf appended the following amplification: particular attention is drawn to the work of Dr. A. Shigo and others in eastern North America on the succession of fungi. Shigo could be invited to present some of his outstanding work, which has direct application to some of our basic problems in the west).

10. Topics from the previous Interim Program Chairman's Report not yet included:

    a. fungus physiology,
    b. information retrieval systems,
    c. population dynamics,
    d. mycorrhiza,
    e. pathological data required for modern computer analysis of the economics of forest management,
    f. role of the researcher, pest control pathologist, and land manager in forest land management.