PROCEEDINGS OF THE 7th ANNUAL WESTERN INTERNATIONAL FOREST DISEASE WORK CONFERENCE

Pullman, Washington
December 1959

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FOREWORD

The Seventh Western International Forest Disease Work Conference was held on the campus of Washington State University, Pullman, Washington, from December 1-4, 1959. Thirty-seven members and 26 guests were registered.

The theme of the Seventh Conference was "Forest Disease Research Serves the Forest Manager." To this end comments were solicited from foresters charged with management and operational responsibilities as well as from those actively engaged in programmes of forest disease survey or research. Evaluations were made of the problems confronting the forest owner and manager, existing guide lines in forest disease control were outlined, and attention was directed to the extended list of questions and problems yet unsolved.

The banquet on December 2nd was highlighted by the after dinner speaker, Dr. Irven O. Buss, Professor of Wildlife Management, Washington State University. Dr. Buss held his audience captive with stimulating references to his recent trip to central Africa. Facets of wildlife not generally appreciated were clearly illustrated in an excellent series of slides and colour film.

December 3rd was devoted to: (1) a tour of the facilities for undergraduate and graduate studies in forest pathology at the University of Idaho, Moscow, (2) an examination of the methods employed by Mr. R. T. Bingham and his associates in the selection and breeding of western white pine resistant to blister rust, and (3) an appraisal of the methods employed and results achieved in the control of white pine blister rust through the use of Acti-dione. These appraisals proved helpful and informative and served as the basis for considerable discussion.

Dr. and Mrs. Gardner Shaw graciously hosted a social hour at their home on the W.S.U. campus following the day of field activity.

A business meeting was held during the afternoon of December 4th. At the conclusion of this meeting members were privileged to tour the Wood Technology Laboratory, Division of Industrial Research, Washington State University.

<u>Executive Committee</u>

H. R. Offord, Chairman
R. E. Foster, Secretary-Treasurer

<u>Programme Committee</u>

C. G. Shaw
G. P. Thomas
D. P. Graham

CHAIRMAN'S WELCOME

Members and guests of the Western International Forest Disease Work Conference: Welcome to our seventh annual meeting!

Miembros y huéspedes del Western International Forest Disease Work Conference: Bienvenidos a nuestra séptima reunión anal!

Députés et invités de la Western International Forest Disease Work Conference: Soyez le bienvenu à nôtre septième assemblée annuelle!

The theme of this year's work conference is "Forest Disease Research Serves the Forest Manager." It's a right good theme, too--particularly for a meeting at Pullman in the heart of the Inland Empire. Under the impetus of threats from blister rust, pole blight, and more recently white pine needle disease, forest managers and researchers in this region have been outstanding in their concern for and their contributions to forest disease control work.

Because of my long association with foresters and disease problems in north Idaho, it is with special personal gratification that I call to your attention the reports that are to be made by our long-time associates in disease control work, Royce Cox, Homer Hartman, Virgil Moss, and Dick Bingham. Mr. Joergensen of Columbia Cellulose Co. and Ray Foster will complete a morning panel which will keynote the special theme of this meeting. The four remaining panels will certainly give us ample opportunity to take stock of (1) disease problems that are of major importance to forest managers, (2) where we stand on the essential job of finding solutions to these problems, and (3) what are the needs and emphasis of future research and developmental work.

May I speak for the Conference in expressing regret that our Mexican colleagues could not be present at this meeting. Also we will all miss Vidar Nordin, Jack Bier, and Willis Wagener, who were unable to make the trip this year.

Most of you know that arrangements and program for this meeting have been made by Gardner Shaw (Chairman), Phil Thomas, and Don Graham. Later, the Conference will want to acknowledge their sustained, devoted, and productive efforts.

I can think of no better way to conclude the Chairman's welcome and to start the work of this meeting than to tell you an old blister rust story about how to get a job started. Years ago there lived and worked in California a camp boss by the name of Phillips. He had a well-deserved reputation for running a sharp camp, a happy camp, and a productive camp. About this time we were all getting the pitch from the Washington Office and elsewhere about how to be an effective supervisor and leader, etc., etc., etc. Now Phillips was to start in a green crew in the field next day, so everyone was on hand when the training session got under way. He took his position astride a gooseberry bush, leaned on his ribes pick, and said, "My name is Bill Phillips. I'm the boss. Your job is to find all of these gooseberry plants and dig them out. This is a gooseberry bush. This is your digging tool. When I want you to start work, I shall whistle once. When I want you to stop work I shall whistle twice." (One whistle.)

My name is Harold Offord. I am the Chairman. Here is the program. It's up to you! (One whistle.)

H. R. Offord
Conference Chairman

FOREST DISEASE RESEARCH SERVES THE FOREST MANAGER

Royce Cox

Having the opportunity to participate in this Conference is a new and welcome experience for me. I appreciate your invitation and hope I can do justice to the assignment given me. I have been asked not only to serve as chairman of this panel, but also to express my views on the theme "Forest Disease Research Serves the Forest Manager." Certainly this is a most timely and provocative theme, one which deserves the "work" stressed in your Conference heading.

I must confess that my task would have seemed easier if the topic under discussion had been presented in the form of a question rather than a positive statement. Of course, I wholeheartedly agree with the philosophy of accentuating the positive, but I hope you will forgive my audacity in pointing to some weak spots and adding the questions, "Just how well is this job being done?", and, "How can we improve this service?"

How well is the job being done?

Frankly, it seems to me that the extent to which forest disease research is serving the forest manager leaves much to be desired. True, we have made significant progress in some fields, but that progress hasn't been nearly fast enough. We are still groping our way through a maze of complex and unsolved problems.

That statement will no doubt cause your hackles to bristle a bit and to think--"This guy sounds like a typical forest manager--impatient and always looking for pat answers to difficult problems." I confess to being impatient; however, my impatience stems from struggling with the problems which confront all practising foresters. The forest manager's job is to coordinate into a well-balanced program all the many conflicting multiple uses of the forest for production of timber, water, grazing, wildlife and recreation. To do this intelligently requires a vast amount of practical knowledge, much of which simply isn't yet available, in spite of the progress which has been made. Developing a permanent, sustained-yield of timber is relatively simple--the real challenge is to grow this timber at a cost competitive with other materials used for the same or similar end products. This factor of cost is one which should receive much more attention from public as well as private foresters. We all recognize that the company, and the nation, which will survive and grow in the ever-increasing competition for world markets is the one which profitably produces high-quality finished products at a price people will buy in large volume. The cost of growing timber is a vital part of the price of the finished product, and the problem of forest disease is a significant factor in the cost of growing timber. We must exert more effort to find better and more economic solutions to our forest problems.

In regard to "pat" answers, my admittedly limited technical knowledge of pathology is still adequate for me to recognize that such answers are not possible for the vastly complex problems of forest disease research. No one can deny, however, that we need much better guidelines for the forest manager than are now available.

Importance of forest disease

The seriousness of the overall forest disease problem is clearly illustrated by the Timber Resource Review. This report shows that in the eleven western United States there is an estimated annual "growth impact" of 13.7 billion board feet of sawtimber caused by all natural destructive agencies, based on 1952 averages. (Growth impact is mortality plus growth loss.) Of this total growth impact, 4.3 billion or 32 per cent is caused by forest diseases. The loss from disease is six times greater than the loss caused by fire and is exceeded only slightly by the loss from insects. It is significant, also, that of the total growth impact caused by disease, only 21 per cent is in the form of mortality; the balance (79 per cent) is a growth loss caused by such factors as reduced vigor and the advance of rot in living trees. Also of significance is the estimate that heart rots caused 45 per cent of the total disease impact, ranking far ahead of any other single disease class. Root rots caused 10 per cent of the disease impact. The total loss from diseases of all kinds is equivalent to 39 per cent of the total estimated sawtimber net growth.

These figures illustrate that while disease may not be as spectacular a killer as fire or insects, it is a tremendously serious problem. The heart and root rots are the most subversive of all forest culprits and deserve much greater attention from forest managers as well as researchers.

The T.R.R. indicates that the future predicted growth of western softwoods will be 27 per cent below needed growth for the medium level demand by 1975. Much debate centers about the accuracy of T.R.R.'s estimates of such things as "growth impact" and losses from disease. My crystal ball becomes rather cloudy when I look more than a few years into the future, but I would venture to say that improved utilization will be the most influential single factor in narrowing this estimated gap. Nonetheless, two of the most pertinent questions facing us today are: Is this gap between needed and projected growth as large as estimated, and if so, how much can it be reduced by economical disease control? These two questions alone raise the need for much better disease survey and research methods.

In my opening remarks, I did not intend to disparage the progress which has been made in forest disease research in the West. A number of valuable results have been achieved, eg., effective (if costly) blister rust control of western white pine with hormone sprays, identification of many severe pathogens, useful guidelines in damage survey methods, and most notable, the recent breakthrough in systemic control of blister rust through the application of antibiotics to the infected tree. You will recognize, of course, that this is only a partial list.

I am disturbed, however, by the long list of unsolved serious and costly problems still confronting us. Some of these problems have received long and diligent study without conclusive identity or solution. Pole blight is a case in point.

Needs of the forest manager

You gentlemen are just as aware of forest disease problems as I am. However, for the purpose of generating discussion, let me list some of the more urgent questions in the minds of practising foresters with whom I have discussed this problem:

1. Are heart and root rots limiting factors in such cultural treatments as pruning and thinning on certain sites?

2. Are we justified in spending money for sanitation treatments to eliminate the source of infection, or put another way, will leaving cull trees intensify the spread of rot in partial-cut stands and reproduction areas?

3. Will leaving defective cull trees tend to develop progenies more genetically susceptible to disease infection?

4. What part does disease play (especially root rots) in the accelerated break up which often occurs in partially cut or thinned stands?

5. Can disease be more economically controlled through silvicultural manipulations, or should we concentrate more research on direct, artificial controls?

6. What is the role of fire as a tool for control of forest diseases?

7. What methods of cone and seed handling and treatment should be followed to minimize damage from molds and other pathogens?

8. Are the losses from dwarfmistletoe severe enough to justify the cost of control, and if so, what are the most practicable control measures?

9. Would more demonstration areas be of practical value in showing disease losses as well as effectiveness of control?

Each of you could, of course, make a much more complete list of your own. This is just a sample of the kind of questions practising foresters ask themselves when they are trying to make decisions regarding the details of managing a timber property. These decisions involve the expenditure of large sums of money, and hence must be based on sound information and reasoning if a budget request is to avoid the red pencil. I realize that partial answers are available for many of these questions, but we need better and more complete answers.

How can we strengthen forest disease research?

Since I have raised the point that our progress in forest disease research has been much too slow, I should give some of the reasons why I think this is true. There are many reasons, of course, not the least of which is the fact that all problems of forest management are greatly complicated by the long periods of time required for solution, simply because of the long-lived nature of trees. Beyond this, however, there seem to be several weaknesses in our program which could be strengthened by more positive approaches.

Following are a few suggestions for your consideration:

1. Develop an action program to increase overall forestry research effort to a level proportionate to the value of the forest products industry in relation to the national and regional economics.

2. Achieve even closer cooperation and coordination of effort among research specialists both from inside and outside the field of forestry. Of course, this must be done in a way which will not kill individual initiative.

3. Work more flexibility into our research programs to enable us to take care of emergencies when they occur.

4. Develop a better system of reviewing and reporting to consolidate the results of disease research into more useful guidelines for the practising forester.

Again, this is not intended to be an all-inclusive list. I am not proposing how the details of these suggestions could be worked out, but perhaps they will at least generate a little discussion. There are two points, however, on which I feel my position should be clarified. First, some of you will recognize suggestion number four as a pet peeve of mine. The need for a better system of reviewing and reporting applies to all branches of forestry research, not just disease. Only a few large firms feel they can afford a full-time pathologist or a project forester to assume the burden of interpreting research findings for practical application. Most practising foresters are too involved with the many details of their jobs to find the large amount of time necessary to wade through the vast array of highly technical forest disease reports to glean information they might apply to their problems. Every forester's office has a large file of such reports which too often just takes up costly space. If more effective summaries and reviews were available, practising foresters in general should show a much greater interest in and support for disease research. From a total cost standpoint, surely it would be more economical to have a cooperative approach to this problem than to have each company and organization attempting to do the job separately. I feel that part of our research money and man power should be budgeted for this purpose. Little good results from research findings unless they are made available to the man on the ground in a form he can use.

At the risk of taking up too much time, I'd like to enlarge on suggestion number one--increasing the effort going into forestry research. Note that I specified "forestry" research and not just disease. Lack of money and manpower is usually the first response when a research agency is asked to study a new problem. Although I feel most research programs could benefit from more flexibility to take care of emergencies when justified, nevertheless there is an obvious need for more money and manpower in forestry and forest disease research.

This is easy to say, but just how can it be done? We all know that competition for the research dollar will continue to increase as our industrial and social structure becomes ever larger and more complex. Each new discovery by research opens up a new field for further research--it's a perpetual chain reaction. While effective research provides the transfusion which enables an industry to meet changing market demands and competition from new products, we must recognize that there are practical limitations to the amount of money which can be budgeted for research. Furthermore, obtaining money for long-term, high-risk projects such as most forestry research, is much more difficult than for relatively short-term projects, such as product development, which have the added attraction of lower risk and usually a higher rate of return on investment. This does not diminish the need for increased emphasis on forestry research.

Meeting the increased demand for forestry research is a difficult problem for which I do not pretend to have a complete answer. However, there are several approaches which I would like to discuss briefly.

1. Industry and private forest land owners should increase their direct contribution--either by employing more forest pathologists and other research specialists, by increasing grants and fellowships to colleges and universities, or by providing more collaborators to assist in the work of state and federal research. I favor this method over asking the federal and state governments to increase their staffs to do the research for us because this inevitably results in requests for bigger appropriations which in turn are reflected in higher taxes. I think we can get a more direct return on our investment through direct contribution, at least on specialized, short-range problems.

2. Improve the program for utilizing the research talents of university professors and instructors having specialized training applicable to forestry problems. I realize these people are required to do research as part of their regular schedules, and perhaps they have little or no free time. They could perform a useful service, however, if they were more readily available as research consultants or collaborators, especially during the summer months.

3. Increase the effectiveness of graduate students and fellows by better coordination of their thesis study with practical problems.

4. Foresters should develop and actively support a program to determine whether or not forestry research is receiving its fair share of public and private money and manpower already allocated to research. To my knowledge, no useable up-to-date comparisons have been made, but data gleaned from various reports shows the following comparisons for 1953:

The total money spent on forestry and related research, nationwide, was 45.5 million dollars, or only about one per cent of the total of $4.0 billion spent on all research in all fields. Of the $45.5 million spent on forestry and related research, only $2.5 million or 2.3 per cent was spent on forest management and protection. The bulk of the balance, or $31 million, was spent on forest product development research. It is significant, too, that $4.6 million was spent on research in wildlife, range, watershed and recreation, or nearly twice that for forest management and protection. (2).

When we look at the relative importance of forest products in the nation's economy, we find that in 1952 it was responsible for about $20 billion (1) or nearly six per cent of the total gross national product. (3) (Compare 1 per cent research expenditures with 6 per cent g.n.p.)

Another interesting comparison is that shown by the U.S.D.A. budget for Agricultural Experiment Stations for the fiscal year 1959. (4). Funds for these stations come largely from state and federal appropriations. The total money budgeted was $139.8 million, of which $1.4 million, or only 1.2 per cent was allocated for "forestry production." Yet nationwide, the value of forest products was about $15 billion, even in 1952, or nearly one-third that of the value of farm products. The proposed Agricultural Experiment Station budget for 1960 has not been published, but I understand the allocation for forestry research has been increased. There is still some doubt, however, as to whether forestry is receiving its fair share.

While these comparisons are by no means complete, they do illustrate that forestry research may be on the short end of the stick. This may be especially true in the West where 66 per cent of the total commercial forest land is in public ownership. A thorough re-evaluation of this situation should be made, just as soon as possible, to provide a basis for the action program mentioned earlier. Combined with this study should be a complete problem analysis of the needs of forestry and forest disease research. I am in general agreement with the idea that we need more basic research to provide the foundation for the applied research necessary for sound answers to the many problems of the forest manager. Perhaps in our impatience we have concentrated too much on the "whats" and not enough on the "hows" and "whys."

One approach to carrying out this study would be for the Society of American Foresters to expand and bring up to date its 1955 report, "Forestry and Related Research in North America." (2). Sections and Chapters could help this project on the local level.

<u>Summary</u>

Forest disease research is serving the forest manager, but not to the extent that it should. Meetings such as this Conference are proof of the dedicated and cooperative efforts of researchers from all agencies--public and private. We must increase this cooperative effort if forest disease research is to develop the information the forest manager needs to fulfill his responsibility to his employer and the public. One of our most urgent needs is for effective and economical disease control. To fill this need we should determine whether or not more basic research is required to provide the foundation for more productive applied research. A thorough forest research problem analysis should be made as soon as possible to develop a more effective and coordinated overall program and to determine if forestry is receiving its fair shore of research effort.

Forest managers should give more support to forestry research in general and to disease research in particular.

Conclusion

We are standing on the threshold of a new era in forestry research. More and more people outside the professional ranks of forestry are becoming interested in the problems of timber growing and harvesting, fish and game, watershed management, recreation and wilderness areas. We should encourage this interest. Foresters face an increasing responsibility to protect and develop these resources to meet the ever-growing pressure of public needs. Forest pathologists have a particularly difficult role because of the "subversive" characteristics of forest pathogens. The difficulty of your problems may be frustrating, but the importance of finding economic answers presents an unavoidable challenge. May this work conference help inspire you to meet that challenge.

References

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FOREST DISEASE - A MANAGEMENT PROBLEM

C. Joergensen

Research into the diseases of forest trees has the ultimate objective: to prevent, and to control tree diseases.

In this there is nothing new, since it is a common introduction to formal textbooks on forest pathology.

It is equally common, however, to read in the last page of the same textbooks, that, unfortunately, the economics of forest management are such that there isn't much we can do about the diseases.

There was a time, about 100 years or so ago, when a forester could go about his business, happily unaware of tree diseases. He knew the effects, and he knew what to do when they occurred--usually salvage of the remains, and cultivation of another species.

He did not have, however, the uncomfortable feeling of killers, cankers, scabs, galls, wilts and diebacks lurking in the shadows, ready to strike at the first sign of weakness.

Today we can diagnose almost any malady afflicting our trees; we can isolate, see, and describe the causal agents of a good many of them; and we have developed effective and practical control measures against a few.

Thus, it appears that we have taken great strides ahead of our great-grandfather - forester and that our research has been fruitful and well worthwhile. All that remains is a last, supreme effort and we may reach the objective of having accumulated all this knowledge: the prevention and control of tree diseases.

This is where the practical forester becomes really interested. His main concern is the effect of the diseases and the possibility of combating the cause. He is not so curious about the fundamental aspects, - or if he is, it would be an intellectual curiosity.

How important are tree diseases when compared with other problems of forest management? - Within the family of destructive agents, the diseases by far outranks fire, insects, animals and weather.

A fairly recent, extensive survey[1] indicated that the total effect on mean annual growth is attributed to:

diseases	-	34%
insects	-	22%
weather	-	16%
fire	-	11%
animals and other causes	-	17%

These figures represent the combined effects of direct mortality, and a novel term: "growth impact", which includes retardation of increment, increase of cull, as well as future effects of site deterioration and mortality at the seedling and sapling stages.

It is interesting to note in this connection that diseases lead the field largely because of this growth impact. Insects kill twice as much volume as do the diseases, and especially in the saw timber class.

These few statistics speak strongly of the importance of diseases in relation to other destructive agents. We may accept the figures at face value - although it is well known that by a few nimble manipulations of figures one could pay off the national debt in half-an-hour, but we should keep in mind that the effect on volume is one thing, and the effect on value is quite another. The total impact of insects may well take the lead in terms of value, followed by fire, diseases and weather.

Trees killed and not salvaged represent lost volume as well as value; so does wood destroyed in living trees. The loss of seedlings and saplings, and the degrading of wood through discolouration, non-structural deficiencies, and incipient decays, can, however, be evaluated in different ways, depending on economic viewpoints, and type of utilization.

I do not intend to become too deeply involved in this line of thought. We are dealing with matters of degree, and with interpretation of statistics. Whether one or the other agent is the more destructive is not overly important in view of the fact that the amount of defective wood in mature forests and the premature death of young trees bear witness of destructive forces that are not to be taken lightly.

Naturally a forest manager is unhappy about losing wood that it has taken decades to produce, and he is upset by outbreaks of diseases that annihilate his nursery stock, or disrupt his normal plan of operations. His yield-and-cut calculations may be thrown out of balance, or he may find that timber quality does not measure up to expectations.

Disheartening as this may be there are other strong factors at work against fulfillment of the objectives of forest management.

Assuming that wood will continue to be a commodity worth producing, one would endeavour to produce as much as possible and as cheaply as possible per unit area available for tree growth.

It would be gross impertinence to claim that we have reached the half-way mark of that objective.

The estimated mean annual increment in the United States is in the order of 30 cubic feet net per acre per year. In Canada it is only one-third of that.

I suggest that the potential growth rate in either country lies over the 100 cubic feet mark - in the United States possibly over 150 cubic feet.

The reasons for such almost unbelievable deficiencies in production are not difficult to find. A large portion of the forests are in the mature and over-mature age-classes, especially in Canada. The net growth is nil because the stands are in equilibrium. Whatever wood volume there is produced is counter-balanced by an equivalent loss from mortality and decay.

We utilize only three-fourths of the wood that is actually cut down. The balance is left behind as non-merchantable pieces, in tops, and as sound wood in cull logs.

The productive forest land is far from being stocked as it could be; less than half of all commercial forest land in the United States is considered well stocked, that is by more than 70% of empirical yield-table standards. If we use 50% of optimum stocking as a grand average we shall probably leave a generous margin.

Intermediate utilization is for all practical purposes non-existent, although we may expect a rapid increase in this direction during the next 10-15 years. A stand that grows at full density throughout the rotation may well have produced 40-50% of the final yield in natural mortality, due solely to competition. That represents wood that could be available, if only we could find a practical way to collect it.

We could go on to refinements such as optimum matching of site and species, reduction of reproduction delay, conversion of potentially high-site lands, such as swamps and brush sites, into the highest yielding stands in the country - and several other practices of intensive forest management.

The point I'm aiming at, however, is not a lecture on forest management and technical possibilities, but a demonstration of the factors that cause the wide gap between actual production and potential production.

Destructive agents rank amongst the principal three factors, together with incomplete stocking and utilization. In fact if all direct and indirect losses from hazards could be eliminated, we could double the present growth-and-cut figures.

Research in tree diseases must carry one-third of that load, or from 5-10% of the total gain that could be realized by advancing the intensity of forest management to its technical limit.

It may surprise you that the science of forest pathology should be entitled only to less than one-tenth of the honour. You may question the validity of the basic statistics, and you may suspect reckless manipulation of figures. Faced with an accusation I'm not prepared for a vigorous defence on either count, as it is merely my intention to give perspective to the total complement of forest management problems, and not to be overly concerned about decimals or statistical significance of the information.

Within that scope I have reasonable confidence in the conclusions, and in a statement that I really wanted to make at the beginning, but didn't dare without some form of factual support: "the role played by tree diseases amongst all the problems surrounding a forest manager is not a primary one".

That seems a strange statement to make in view of the large volumes of defective timber we run into occasionally, and with catastrophies such as birch dieback and the Dutch Elm disease freshly in mind.

We should not loose sight of the fact, however, that defective timber is primarily the result of old age, something that we have inherited together with mature forests. In a purely pathological sense the problem is beyond our control, and has become one of utilization. In the future we shall be only too anxious to harvest our trees before they grow to an age where decay balances growth.

Epidemic outbreaks of diseases can indeed cause catastrophic losses as it has been experienced in the East. Locally the results may be disastrous, and there I can see one of the forest pathologists' most honourable duties: "to be on guard against epidemics, whether they be of local origin or be introduced from other regions or countries."

It would be a neat and ideal exit if I could propose an array of specific diseases and disease problems requiring your particular attention, but I am confident that you appreciate the futility of any such attempt. Disease problems vary in importance from region to region, and locality, as do species and environment.

I can, however, give an indication of what hurts the most from a forest management point-of-view.

As mentioned before, the life span, say from 0-100 years, is the critical period as far as prevention and control of diseases go. What we now suffer beyond 100 years, or to be more exact: rotation age, has happened and need not happen again. That does not mean that we can dispense with the aid of pathologists in managing mature stands - on the contrary we could do with more attention to means of detecting, locating, and identifying defects in standing trees, felled trees, and in logs.

The cruisers, fallers, and the scalers are still very much handicapped by not being able to search beyond the surface of trees and logs.

A good deal of excellent work has already been done in that direction, and you should not get the impression that the results are not appreciated and applied. In a related category we find the studies in rate of deterioration of dead timber a most useful contribution towards efficient management.

The immature age classes, together with the seed and seedling stages, are, however, the preferred fields of activity, and rightly so, because that is where the growth impact originates and develops.

I have the greatest respect for diseases that attack and destroy just on the borderline of merchantability. Thirty to forty years of investment and costs have accumulated without much chance of significant recovery.

Diseases that strike at say 60-80 years, or later, may cause inconvenience and possibly some direct losses, but there is a possibility of economical salvage if the stands are accessible. Even if the attack is so severe that the stand is broken up and must be regenerated, perhaps 10-20 years earlier than planned, the loss in mean annual increment should not cause too much concern.

Diseases of seed and nursery stock, and to some degree young plantations, are in a different category, for two reasons: they occur at the early stage where investment and costs are still at a minimum, and secondly: prevention and control is so much easier and more effective in the seed-bed or transplant nursery. The worst that can happen is a 2-3 year setback, temporary shortage of planting stock, and perhaps a forced replacement with another species. All this can be bad enough, but rarely does it attain unmanageable proportions.

And this brings to an end my excursion into a subject on which I can speak not only with an amateur's authority, but with an amateur's courage and disregard for pitfalls.

Have I no positive suggestions? Yes, one: there is a last hurdle to be taken - the development of economical and practical means of preventing and controlling a large number of tree diseases. There is a gap between the extensive fundamental knowledge, accumulated by the pathologists, and the practical forester's need for methods of putting this knowledge to good use. The most practical solution seems to be that the forester and the pathologist join forces, in terms of funds, time, and skill. The scientist must sacrifice some part of his preference for basic research. He must work and write at a level where he can be reached and understood by the practising forester, who has neither the time or the knowledge to carry the results alone from where the scientist left off.

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   Forest Service
   U. S. Department of Agriculture
   Forest Resource Report 26.14. 1958.

FOREST DISEASE RESEARCH SERVES THE FOREST MANAGER

H. J. Hartman

I welcome the opportunity to speak before the Seventh Western International Forest Disease Work Conference on the subject "Disease Research Serves the Forest Manager". I am a forester by training and have spent most of the last 30 years conducting forest insect and disease control work in the Inland Empire. My remarks are confined to this Region.

In 1952, the net sawtimber growth in the United States would have been about double if it had not been for the effects of these agencies (disease, insects, fire and other destructive agencies). Growth-loss causes were 45% due to disease, 20% to insects, 17% to fire and 18% to other destructive forces. This Region has its full share of tree diseases.

Far more emphasis is being placed on insect and fire research individually than is placed on forest tree disease research, even though diseases cause more growth loss than insects and fire combined.

Forest tree disease research should be increased three or four times the present level.

Some forest managers are doing little or nothing about disease control mainly because they need instruction and guidelines based on sound research. Of all the tree disease in the Inland Empire, a major effort is being made to control white pine blister rust and a very minor effort to control the dwarfmistletoes. All other diseases are still at large.

The greatest single cause of growth loss in this Region is over-stocking. Any time there are more stems per acre than a given site will support for a particular age and species the stand becomes stagnant and weakened. Over a long period of years insects, disease and other agencies move in and reduce the basal area to somewhere near the carrying capacity for the particular site. This is crude and costly silviculture. From the pathological angle the land manager needs to know the optimum number of stems per acre for each site for a particular species at any given age. Chances are that optimum pathological stocking will also be ideal from the entomological and maximum growth angle.

A problem analysis should be made of the entire forest tree-disease situation in the Inland Empire. Arrange by priority the diseases most in need of control, then concentrate research efforts on top priority diseases.

I would like to see the research team approach used to determine the real underlying cause for a particular disease. The forest pathologist should have the aid of the forest ecologist, plant physiologist, geneticist, entomologist, climatologist, biochemist, forest soils specialist and others.

Forest tree disease prevention is often more important to the land manager than control. Very little information is available on disease prevention.

Forest tree diseases determine the natural rotation for the same tree species on different sites, a longer rotation of good sites, and a shorter rotation on poor sites. The land manager would prefer to look to the forest pathologist for guidance on how to properly manage his forest pathologically rather than having tree diseases dictate the rotation.

Sound silvicultural and pathological practices at the time of stand re-establishment are the key to forest disease prevention in some instances. Adequate site preparation coupled with the proper nursery stock for the site plus correct tree spacing will place a stand well on its way to a healthy and productive life.

The most logical way of correcting many of our pathological mistakes of the past is through intensive forest management in the near future. Forest access and general economic conditions have greatly improved in the last few years. The land manager is now in the favorable position of being able to remove at a profit far more low grade material from his forest than ever before. Adequate forest access roads and favorable markets permit the land manager to direct his timber harvest as to time and place to assure a pathologically healthy stand. Sound pathological guidance is needed plus a strong selling force.

It is important to know how to control a disease and the cost of control, but the first question asked when a request for funds is made is - what growth loss in volume or dollars is the disease causing? Information on growth loss due to dwarfmistletoes is urgently needed at this time. Is research or administration responsible for determining growth loss?

The land manager wants to be kept well informed of your research program. Make him a working partner whenever possible. Your findings will be more readily accepted and put into practice. Above all, keep your facts separated from what you think.

As a work of caution, the pathologist should not set himself up as a forest economist, because the land manager knows that even a real forest economist finds it difficult at times to avoid unemployment. Give the land manager the facts and let him draw his own conclusions. The land manager must consider his insect, disease, silvicultural, and economic problems and then strike what he hopes is a profitable medium.

We have been fighting white pine blister rust in the Inland Empire for 40 years. Over this 40-year period, we have developed the following present-day control methods, techniques, and possibilities:

1. Direct control through hand and chemical eradication of the alternate host -- ribes.

2. Applied ribes ecology:

    A. Silvicultural practices
    B. Controlled burning
    C. Logging methods

3. Applied climatology.

4. Blister rust-resistant planting stock through forest genetics.

5. Application of antifungal antibiotics:

    A. Basal stem treatment
    B. Aerial application by aircraft
    C. Immunization of nursery-grown western white pine seedlings.

A good example of how disease research serves the forest manager is Mr. Virgil D. Moss' highly significant contributions to forestry through pioneering and developing the use of antifungal antibiotics to control white pine blister rust. To my knowledge Moss was the first man to control any forest tree disease with an antibiotic. His developmental work represents a complete breakthrough in blister rust control. Moss will report his discovery to you tomorrow, but I would like to point out the large scale field application we have made and future plans for the application of antibiotics for the control of white pine blister rust in the Inland Empire. Only 1/3 of the western white pine type is included in the present blister rust control program. To establish control units it has been necessary to analyze the existing stands, as to the growth, and yield at time of cutting, in relation to the cost of control; and to spend limited funds on those units which can produce the greatest volume of white pine per dollar of control cost. On this basis large areas have been abandoned to the rust. Other immature stands inside control units are up to 50% infected with lethal cankers, and until Moss' discovery nothing could be done about it. We now plan to increase our control area from the present 1,000,000 acres to 2,000,000 acres in the near future.

During 1958 and 1959 we treated by basal stem method 4,300,000 reproduction and pole-size trees on 19,000 acres. This treatment required 1/2 man-day per acre. On each area all white pine stems were treated, as this is cheaper than to spend time looking for infection. We plan to treat 8,000,000 trees by the basal stem method in 1960.

In June 1959, antibiotics were applied aerially by helicopter. Fourteen 10-acre plots were sprayed. These plots supported mature, pole and reproduction-size trees. Results of these tests will be known in June 1960. If the results prove satisfactory 1,200 acres will be sprayed by helicopter and fixed-wing plane in June 1960 and 10,000 acres in September.

There are upwards of 3 billion board feet of young mature western white pine in northern Idaho that are lethally infected with blister rust. Damage surveys indicate that 67% of these trees will be lost to blister rust during the next 20 years. Aerial application of antibiotics by helicopter or fixed-wing plane will add an additional 30 years of life to these infected trees. This will permit an orderly harvesting of these stands plus added increment. The cost of treatment will average $12 per acre.

If it is possible to develop 4 or more years of immunity to blister rust in nursery stock by application of antibiotics, it will permit early planting of broadcast burned areas before ribes are removed and before the areas become heavily brushed and sodded. Thus, 3 to 7 years can be saved by prompt stand re-establishment.

By application of antibiotics, it is now possible to protect, at reasonable cost, small areas of presently established western white pine occurring on recreational areas, farm woodlots and stands of high esthetic value, without ribes eradication. In the past such stands have been excluded from the control program due to the ratio of acres protected in relation to the amount of non-pine producing protection zone that also needed to be freed of ribes.

We estimate that 60% of our present control area can be carried through to maturity by periodic application of antibiotics and without additional ribes eradication.

The blister rust control program is being greatly expanded in Region 1 to include many western white pine reproduction and pole stands that are outside the present control program. These stands will be brought through to commercial maturity by periodic application of antibiotics and without ribes eradication. Infected trees in presently protected stands will be treated with antibiotics to assure adequate stocking. The stumpage values protected through antibiotics during the next 60 years will exceed $700,000,000 at an estimated control cost of $30 to $40 million.

The indications are that other Cronartium rusts and other forest tree diseases throughout the world may be controlled through application of antibiotics. The forest pathologist now has a new working tool. There are several promising antibiotics, many formulations, and several ways and means of application -- don't give up too soon.

We have white pine blister rust on the run, but there is still a dozen important tree diseases that we should be running out of the woods. The forest manager urgently needs and welcomes your help - now.

TRENDS IN FOREST PATHOLOGY IN WESTERN CANADA

R. E. Foster

Although the title of my paper provides freedom for considerable scope, my comments will be directed for the most part to trends in forest pathology in Alberta and British Columbia that are likely to emerge within the next decade. I will refer to past or present trends only insofar as these appear to have established guide lines for our further development.

Our future development can be anticipated, in my opinion, with some degree of confidence. The basis for this confidence arises partly through an appreciation of our historical development, and partly through recognition of forest disease problems towards which little or no action has been taken to date.

The early progress of forest pathology in western Canada was conditioned by the state of vigour of the forest industry. The British Columbia and Alberta Laboratories can trace their establishment, and much of their subsequent development, to several important forest disease problems, and to the extent that concern was expressed in regard to these problems by forest owners and managers. This historical evidence serves to verify our Departmental objective; namely, to promote a healthy and vigorous forest economy through the solution of forest biological problems. There would appear to be no reason to believe that our future development will be based on any different principle. Appreciation of the problems that are likely to confront and be of concern to the forest interests in the future is likely, therefore, to forecast the trends to be anticipated in forest pathology.

The basic problem confronting the forest owner and manager in British Columbia today is that of maintaining a competitive position in world markets. This problem is likely to be with us throughout the next decade. Can we maintain our present position following depletion of our old growth forests? This is a question of basic concern to many foresters today. Towards its solution two developments have been forecast: closer utilization and greater attention to the factors that depreciate forest growth and quality. Efforts to control the factors that extend rotations and depreciate quality of growth require further stimulation before they are universally practised, but trends in this direction are apparent and in my opinion establish in part the guide lines for our further activities.

I anticipate four developments in forest pathology in western Canada within the next decade.

In the first place I am confident that there will be an increasing awareness of the need for more intensive forest disease surveys. I anticipate that we will be called upon to undertake more intensive damage appraisals and to define more precisely the circumstances that are associated with severe damage. It should be recognized that we do not now fully appreciate our native fungus flora, the rate of spread, intensification, or significance of many of our currently recognized forest diseases, how to evaluate forest habitats, or how to sample forest diseases within acceptable limits of precision. Until this information is gained, our forest disease survey will have little opportunity to completely fulfil its primary objective; namely, to detect, identify, record, and interpret the significance of tree diseases. Is it not possible that forest disease surveys will be undertaken in the near future by forest owners and managers? It seems to me that some aspects of the survey could readily be incorporated in existing inventory appraisals and that more detailed information could be gained through special surveys. Trends to these latter developments are already apparent and I predict that these trends will be consolidated and extended as reliable methods of forest disease sampling are developed. I visualize that forest disease surveys will be recognized as a joint responsibility. The forest interests might concern themselves with the detection and severity of disease and the Forest Biology Division might concentrate its effort on identification, interpretation of significance, co-ordination and dissemination of pertinent information, and appraisal of the framework of circumstances associated with severe damage.

The second development likely to influence the direction of our activities is the increasing concern with regard to problems affecting plantations and second growth forests. For the most part we are still in an old growth economy and we are likely to retain our dependence on this class of growth for some time to come. Before our last acre of land is 'alienated', however, there will be a universal appreciation that our future rests with the establishment and proper maintenance of the new forest. This appreciation will extend to the selection of forest habitats adapted to particular species, and to silvicultural and management practices encouraging optimum growth and quality and contributing to the control of important forest pathogens. Factors of forest depreciation, such as foliage disease leading to reduction in growth, cankers and stains leading to reduction in quality, and root rot leading to mortality, may be elevated to a more prominent position of concern than is now apparent. Current research on these latter problems, designed to anticipate the requirements of more intensive management in the future, is likely to be extended. I would suggest that the first evidence of real concern with the problems of second growth management will develop in relation to dwarf mistletoe. If mistletoe can in effect double the length of the rotation required to produce a given product, to say nothing of its depreciation of wood quality, it is surprising that real concern has not arisen to date. If we are to provide technical counsel in relation to the control of this disease within the next decade, it will be necessary for us to take steps very shortly to gain regional information on its distribution, severity, ecological tolerances, and rate of spread and intensification. Beyond this it would be helpful to initiate experimental and demonstration or pilot stage control.

The third development to be anticipated in the near future is greater emphasis on control. What practical methods can we suggest to the forest owner and manager to effect control? Few of us have a satisfactory answer to this question; for the most part we explain that it is necessary to obtain essential background information on the habits, ecological tolerance, biology, and physiology of the particular causal agent in question before a realistic approach can be made to effect reduction in damage. Any other approach is "ad hoc" we say. Notwithstanding the benefits of basic research, is it not possible that empirical control could lead to important contributions, is it not possible that we might increase or decrease the severity of disease through some practical manipulation of stand composition or density, and is it not possible that some proportion of our basic research might then realistically be directed to an explanation of why these results were achieved? Would it not be refreshing, as Nordin (1) has stated, to reverse our normal course of action towards control when we can take advantage of this approach? I am of the opinion that it would be enlightening as well as refreshing. I am of the further opinion that if we do not devote greater attention to control we may strengthen a current opinion that we are disinterested, that we have nothing to offer, or that it is beyond our function. This is not a call for abandonment of basic research, it is a call for a greater balance in our programme than now apparent. I predict that this call will be echoed within the next decade and that we will be unable to ignore it.

The fourth development that I anticipate in the near future is movement towards co-ordination of research. Much sense and much nonsense has been heard on this subject but several conclusions seem to have emerged: (1) surveys and research in forest disease are not independent of other forest disciplines, (2) contributions in one field often aid in the understanding within another, (3) it is essential to maintain a well-balanced, effective, and vigorous programme of research throughout the scope of forest activities, (4) there is need for a more effective method of informing allied research workers of our problems, programme, and contributions, and (5) if we do not find a solution to the latter problem action may very well be taken to effect co-ordination through regimentation. Herein, in my opinion, lays our greatest challenge, - can we co-ordinate and still retain freedom for individual thought and action 'in an atmosphere relatively free from conflicting responsibilities'?

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FOREST DISEASE SURVEY IN BRITISH COLUMBIA

A. C. Molnar

INTRODUCTION

According to the program I am slated to speak on survey methods and techniques. I have taken the easy way out by outlining our approach to disease survey in British Columbia and have done so largely for selfish reasons; namely, to stimulate constructive criticism.

A little background may be helpful to understand our organization and approach. Forest disease investigation in British Columbia was initiated on a continuous basis with establishment of a permanent Laboratory in 1940. Data on the occurrence and distribution of diseases accumulated from the outset, largely in relation to the then existing emphasis on diseases of mature and overmature timber. Reorganization within the Science Service, Canada Department of Agriculture brought the sister disciplines of Forest Pathology and Forest Entomology together in the Forest Biology Division in 1951 and established the disease survey as a formal function of the Laboratory for the first time. The entomology group brought with it a nationally organized survey section with the unique feature of establishment involving the use of Forest Insect Rangers assigned to permanent ranger districts for insect observations. Subsequently the Forest Insect and the newly formed Forest Disease Survey were brought together under national co-ordination and the Forest Insect Rangers were renamed Forest Biology Rangers with responsibilities to both forest insect and disease survey. Needless to say, considerable training and indoctrination were necessary to bring the Rangers up to an acceptable level of contribution to the disease survey. The annual and long-range aspects of the survey program are worked out by collaboration of the Forest Insect and Disease Survey Officers based on the importance of problems and the available establishment.

The primary objectives of the forest disease survey are to detect, identify, record and interpret the significance of forest diseases in Canada. Spelled out in more detail, we are guided in British Columbia by the following objectives:

1. To detect the occurrence of new or previously unrecorded diseases and disease agents affecting B. C. forest stands from seedling to maturity.

2. To identify the causal agents of disease.

3. To accumulate information on the geographical, seasonal, and ecological distribution of agents of forest disease.

4. To evaluate the nature and extent of host damage.

5. To interpret the findings of the forest disease survey and make recommendations for further study when warranted.

6. To publish the results of the forest disease survey in the Annual Report of the Forest Insect and Disease Survey or other publications as the situation warrants.

DISEASE SURVEY ORGANIZATION AND ESTABLISHMENT

In order to meet the objectives of the survey two broad functions of forest disease survey are recognized: Survey, and Taxonomy. The personnel establishment to carry out these functions consists of 24 persons, including 4 Research Officers and 3 full-time Assistants with direct responsibilities to the survey. That may seem like a substantial establishment, but when one considers the total commercial forest area of British Columbia of some 118 million acres, and adds to this the forest areas of the Yukon Territories for which the Victoria Laboratory is also responsible, it becomes somewhat less impressive. Fortunately, co-operation is received from outside sources including the B. C. Forest Service, the Forest Industry, the University of

British Columbia, and the general public. Without this co-operation it would be difficult, if not impossible, to undertake a comprehensive appraisal of forest disease.

SURVEY OPERATION

I should like to turn now to the more formal functions of forest disease survey in British Columbia. The methods by which the forest disease survey organization, just outlined, endeavours to meet its objectives may be covered under the following headings:

1. General collections and observations
2. Special collections
3. Preliminary examination of noteworthy diseases
4. Special surveys
5. Survey research
6. Sampling method studies

General collections and observations

General collections, that is pathological collections and observations made at random as they are encountered, build up our records of disease and disease agent occurrence and distribution. It is from this function of the survey that most of our new records are gained; some 30 to 45 per year over the past few years. Each collection is accompanied by an enclosure slip which forms the source document for the collections and ensures the recording of certain necessary observations.

Special collections

Each year certain specific diseases or specific hosts are designated for particular attention. These serve the same purpose as do the general collections, but efforts are more specifically directed toward filling gaps in the distribution records of known diseases and gathering phenological data or other pertinent information. In the past few years we have emphasized dieback and canker diseases and in 1959 a start was made toward the accumulation of data for a check-list of the genus Pinus on a national basis. We also receive requests for special collections from staff members on project work, from other Laboratories, the Mycological Unit in Ottawa, and Universities. Special collections have the added benefit of training Rangers in specific disease recognition.

Preliminary examination of noteworthy diseases

A more detailed report than is conveniently recorded on enclosure slips is required for particularly noteworthy disease occurrence encountered. A special field procedure and report form is used for this purpose. The form was designed to guide the user in making a systematic and reasonably detailed examination. Such reports and attendant collections form the basis for further action or report to co-operators.

Special surveys

Special surveys are designed to gather specific data on particular diseases or particular classes of host trees. They fall roughly into three types depending on the duration of observations:

1. Long-term plot studies
2. Repeated disease progress observations of a shorter duration.
3. Short-term detailed surveys of specific diseases.

1. Our long-term permanent plot studies include annual observations on a representative sample of exotic plantations and on pole blight.

2. Repeated disease progress observations of shorter duration include such studies as the effect of severe frost injury to yellow pine, fume injury, and disease progress plots established to study specific diseases.

3. Short-term detailed surveys of specific diseases by and large take the form of problem analyses. Previously unrecorded disease outbreaks or unusual outbreaks of known diseases come to our attention from time to time. Where warranted and when time permits, special surveys are conducted on these problems to appraise damage, to determine their causal agents and where possible to assess some of the factors influencing their build up to outbreak levels. Such surveys may culminate in a final report on the basis of one examination, may require further observation, or may be recommended for project status.

When the nature of the problem permits, special short-term surveys are carried out in the spring or fall outside the regular field season using Forest Biology Rangers on the field crews and the Survey Forest Biology Assistant as Party Chief. A survey of Douglas fir decline in the Interior Wet Belt was handled in this manner in October, 1959. During the same year a survey of Elytroderma needle blight of yellow pine was carried out by the Survey F. B. A. and student assistants.

Survey research

Survey research projects, carried out within the general framework of the disease survey, are set up to solve problems which hinder the carrying out of meaningful surveys of particular problems. The determination of causal agents, a study of their life histories, symptomology, phenology, and the development of suitable methods for testing disease pathogenicity would fall into the category of survey research. Recent examples include studies of Douglas fir frost damage and of a disease complex involving a Ceratocystis sp. and the bark beetle Dryocoetes confusus Sw.

Sampling method studies

One of the reasons I have confined my discussion to the more or less broad aspects of survey approach is that we are still lacking in the more finite techniques of disease sampling and appraisal. This is the greatest single obstacle in the way of meaningful disease intensity and damage appraisal surveys. We are only on safe ground when we confine our interpretations to the 100 per cent tally on the plot or small stand basis. But we will have to do more if we are going to interpret the significance of our diseases accurately or presume to make predictions. Accurate disease intensity or damage appraisal surveys are a prerequisite to an intelligent application of disease research findings by forest management.

Work toward this end was initiated in Victoria, starting with sampling techniques for a limited number of diseases on Douglas fir plantations. It is hoped that at least some of the lessons learned in this initial study will find application with other disease and forest types and make future sampling studies easier.

TAXONOMIC SECTION

The other broad function of the survey to which I referred in my introduction,is taxonomy. The taxonomic section, headed by a senior mycologist, is designed to accommodate three general activities.

1. Herbarium
2. Survey identification and mycological research
3. Survey identification and cultural research

1. Herbarium

The herbarium serves the usual purposes understood for herbaria, housing reference material and mycological research material. In addition to mycological material a large collection of phanarogamic plants are on file to provide reference material to ecological associations and alternate hosts of disease agents.

2. Survey identification and mycological research

Part of the senior mycologist's time is devoted to the identification of collections submitted through the survey. He is assisted in this work by a full-time assistant technician. The remainder of his time is devoted to mycological research on the forest tree rusts and Hypodermataceae of conifers.

3. Survey identification and cultural research

While we have handled the cultural identification of wood-destroying fungi for some time, the cultural identification of Ascomycetes and Fungi Imperfecti has remained largely unexplored. Steps were taken to overcome this difficulty with the appointment last year of a second mycologist to the survey staff. This mycologist has the responsibility to handle the cultural identification of survey material and to carry out research on the techniques of cultural identification. As a start he is working on dieback and cankers of conifers. He is assisted by an assistant technician who is competent to undertake cultural identifications within the Basidiomycetes.

This completes an admittedly general outline of our approach to disease survey in British Columbia. Perhaps ensuing discussion will lead more to the core of the subject.

THE FOREST DISEASE SURVEY OF CALIFORNIA

Hubert H. Bynum

The forest manager is a busy man. He is charged with many varied responsibilities including planting, allowable cuts, harvesting methods, road building, and protection to name but a few. Since he cannot be an expert in all fields, he asks help--and he is certainly entitled to it. Of those engaged in forest disease research he asks, "What diseases are present in the forest and how widespread are they? What do they mean in terms of increment loss or mortality? Will they spread and endanger other stands?" and finally, "What can be done about them?" To find answers to these questions in California, the Division of Forest Disease Research at the Pacific Southwest Experiment Station works in the three broad, and sometimes overlapping, areas of survey, fundamental research, and control investigation. This paper concerns itself with survey.

The forest disease survey of California has a dual purpose. First, to obtain statistically sound data on the distribution and intensity of disease and to disseminate this information through Station media. And second, to furnish detailed information on the impact of disease on trees as individuals and as stands. In other words, we want to know what diseases we have, where they are, and how much damage they are causing. This information is important in any long range forest management plan or forest disease research program.

To best meet the objectives of the survey, the work has been divided into two phases. An extensive phase of random temporary plots will be used to determine disease distribution and intensity. Disease impact will be studied in the intensive phase, by utilizing carefully chosen permanent plots. Initial emphasis is being given to the extensive phase of the survey to obtain needed information on the distribution and intensity of our more important diseases. The judicious placement of the more costly disease impact plots will be facilitated by the extensive survey. The large number of random temporary plots will enable us to estimate the statistical reliability of the data within determined limits. It will also give a good initial coverage of the Region and a good distribution of samples over a period of time. Information on disease distribution and intensity will be available for use in 4 or 5 years and will be more complete and accurate with each additional year of survey. The flexibility of this method permits a rapid increase or decrease in the scope of work to compensate for manpower or budget changes.

The forest land of California has been divided into subregions, each representing different forest and economic conditions. For sampling and reporting purposes, the redwood-Douglas-fir and the westside Sierra subregions have each been divided into a north and a south half, giving a total of seven subregions. The redwood-Douglas-fir subregion occupies the western slopes of the north coast ranges. The Coast Range pine subregion, forested chiefly with Douglas-fir, ponderosa pine, and true firs, is located on the eastern slopes of these ranges extending to the Sacramento River. The westside Sierra subregion, with its fast-growing pine forests and stands of mixed pine, Douglas-fir, and fir, lies between the Central Valley and the Sierra Nevada-Cascade divide. The eastside Sierra subregion, with its slow-growing pine forests, is located to the east of the crest. The southern California subregion includes the remainder of the State. The widely scattered pine and fir forests in this unit have greater value for recreation and watershed protection than for timber production.

Levels of reliability for the extensive survey will be referenced to particular disease-host indices for each of the subregions. A similar level of reliability will be maintained for all subregions with the possible exception of southern California, which will probably be at a lower level. The two economically most important disease-host combinations for each subregion will be used as indices. For example, in the three subregions in the Sierra, dwarfmistletoe on pines and heart rot in the true firs will be used as indices. A probability level of 90 per cent will be used. The survey will be continued until the fiducial limits are reduced to ± 10 per cent of the value of the sample mean.

The new sampling method was described briefly under New Techniques in the Proceedings of the 1958 meeting. The survey is being conducted at two levels of sampling. Because of accessibility and cost factors, the "back country" will be sampled at a lower rate than the less remote areas. With enough samples we can determine whether there is any significant difference between the back country population and that of the more intensively sampled area. If, as we expect, no significant difference is found between the populations, the results can be combined for a single mean representative of an entire subregion.

The first sampling level includes all areas within 22 chains of any road passable by a pickup truck. Each timbered township within a subregion is given a number. Uniform metal tags bearing numbers corresponding to the townships are drawn from a container as a step in determining the location of plot reference points. Tags numbered from 1 to 36 correspond to sections, while others numbered from 1 to 80 indicate the number of chains across and down from the northwest corner of the section and thus locate the plot reference points. From the plot reference point, the shortest possible straight line is drawn to a road, even though the line may intersect the road outside of the township containing the reference point. All of the possible starting points for a plot are located on this line within a zone of 2 to 22 chains on either side of the road. To avoid the influence of roads, areas 2 chains or less from a road are excluded from the sample. The place where the line intersects the road is referenced to the nearest tenth of a mile from some determinable feature common to both the ground and the map. Section lines, stream crossings, and road junctions are commonly used. Tags are drawn in the office to indicate the direction and distance to the plot starting point and for the azimuth of the first line of strip.

Each sample consists of a sawtimber plot, a pole subplot, and a seedling-sapling subplot. The sawtimber plot consists of 25 conifers 11 inches d.b.h. or larger. These trees are taken on a strip 1/2 chain wide and up to 50 chains in length. The strip runs 10 chains in the direction of the random azimuth; then, after an offset of 1 chain to the left the direction is reversed and the strip continued for a maximum distance of another 20 chains. If 25 trees have not yet been recorded, a 2-chain offset is made to the left and the direction again reversed. In the event that 25 trees are not recorded on 50 chains of strip, the plot is considered to be nonstocked and is discarded. The length of strip for each plot is recorded to provide acreage figures. Although the sawtimber plot is based on a sample of 25 trees, both the pole and the seedling-sapling subplots are of a fixed size. The pole subplot begins at the 25th tree and continues for 2 chains in the direction of the previously recorded trees. Data is taken on trees having a diameter of 5.0 to 10.9 inches. Seedlings and saplings are recorded on the last 1/2 chain of the pole subplot. Seedlings and saplings are grouped by species and size class and are not tallied as individuals.

The second sampling level will consist of a smaller number of plots to sample the "back country."

Plot and tree data are recorded in code in the field and later transferred directly to 80-column IBM punch cards. The system of recording in code has proved quite satisfactory. Codes that are used often are soon committed to memory. The code sheets are indexed and mounted on the tatum for ready reference by the recorder. The plot form reported at the El Paso meeting in 1956 is used to record data. Species and diameter, as well as Dunning, Kean, risk, and merchantability classes are recorded for each tree. Included under pathological data are: injury, bole wounds, abnormal growth, per cent cull in board feet, heart rot, dwarfmistletoe, foliage diseases, rusts, root disease, physiological disease, and true mistletoe. Each disease and injury is classified according to kind and intensity. Per cent cull in board feet for red and white fir, Douglas-fir, and incense-cedar is obtained from Dr. Kimmey's cull factors for these species.

To sum up, we expect the extensive phase of the survey to yield statistically sound data on disease distribution and intensity, per cent of infection by various diseases, and decay loss as determined by cull indicator factors. It will also serve to keep the Station informed of current disease conditions. Detection reports from cooperators and scouting notes of the field crews will aid in determining the range of diseases. This information, of course, cannot be used in any statistical treatment of data.

The intensive phase of the survey will consist of a smaller number of permanent disease impact plots. These plots will provide detailed information on host-parasite-environment relationships, degree of infection as it affects increment loss, timber drain through mortality caused by disease, and the effects of cutting methods on disease development.

FOREIGN DISEASES - THREATS TO WESTERN FOREST TREES

Thomas S. Buchanan

Since this is a Western international forest disease work conference, I know I don't have to get up here and beat the drums in order to convince you people of the present and potential importance of foreign tree diseases to our own western forest economy. You are all only too well acquainted with the problems created and losses caused by the unfortunate introduction of white pine blister rust into western North America from Europe about 50 years ago. Many members present did their pathological research teething on blister rust problems, and some of you are still chewing away at more highly refined aspects of that same problem. Our Eastern counterparts have had similar experiences, perhaps even more bitter than our own, not only with white pine blister rust but with the introduced chestnut blight that virtually eliminated a highly valuable forest tree species and with the Dutch elm disease that still plagues foresters and arboriculturists alike. Fortunately larch canker was detected reasonably early and successfully eradicated, thereby preventing another eastern, and perhaps eventually western, forest disaster.

Countrywide, the score now stands at 3 to 1; three introduced major diseases firmly entrenched and but one successfully nipped in the bud! There are several ways to evaluate the losses caused by these introduced forest tree diseases, and even when considering just the dollars and cents involved we have two categories of costs that run into staggering amounts:

1. The value of timber actually destroyed.
2. The tremendous costs of control efforts. These may eventually exceed the value of timber destroyed but they must continue if we are to protect the remaining suscepts.

Then there are the innumerable indirect losses that are more difficult to evaluate. Think for a moment, if you will, about just one; how much further might we have progressed in our research and control efforts on some of our native forest tree diseases if the millions spent on white pine blister rust research and control alone had not been necessary but if these same funds had been made available for other constructive purposes? Millions of acres of dwarfmistletoe infected stands, for example, could, I am sure, have been "sanitized" with resultant long term benefits.

There are two subtle features common to introduced diseases. The first, as typified by the introduction of *Rhabdocline pseudotsugae* into Europe from North America, is the long time that may elapse between original entry and the unobserved build-up to epiphytotic proportions. Chestnut blight, as another example, was introduced into Italy from the United States probably during World War I but was not discovered until 1938. And going back once again to our own experience with white pine blister rust - it was far too late to lock the barn door when it was finally discovered the horse had been stolen.

The second insidious thing about introduced diseases is that they characteristically tend to be more destructive than our native diseases. New suscepts, without previous exposure to the specific pathogen and hence without benefit of generations of natural selection for resistance, may fall easy prey. Then, too, the causal organisms, just like we humans, may and often do seem to enjoy a change of climate as well as a change in diet. I say characteristically they may be more destructive but perhaps this is not always so. I am thinking now specifically of Chrysomyxa ledi var. rhododendri which in its European and Asiatic alpine haunts causes a rather destructive needle disease of spruce. I'm not absolutely sure it was introduced into North America from abroad but it could have been for we do have the same fungus on rhododendrons here in the West. For the time being at least it is perfectly harmless to our native spruces because, for some reason, it fails to produce telia on the rhododendron alternate host. But my point is, in any event, that we have far more than enough serious forest tree diseases of our own without importing any from abroad - as much as it may be all the vogue to disport ourselves with "imported" merchandise. And, of course, other countries feel exactly the same way about us. Right now, for example, 8 countries in Europe, Asia, and Africa have rigid restrictions on the importation of oak products from the diseased area in the USA for fear of introducing oak wilt into their own forests. Nor do the Italians have any reason to thank us for chestnut blight, nor the British for Rhabdocline.

The ideal way to handle this problem of foreign forest tree diseases is, obviously, to prevent their introduction in the first place. Our plant quarantine regulations and inspections are much more rigid and efficient now than when white pine blister rust and chestnut blight gained entry many years ago. I can best illustrate this improvement by citing an inquiry I had recently from our quarantine people as to what risks there might be of introducing an undescribed and hence potentially dangerous gall rust of hard pines through allowing entry of Bonsai trees, the ornamental dwarfs perfected by the Japanese. Now these come in only in small numbers, hand carried by returning tourists and military personnel, so you can see that our plant quarantine inspectors are alert. But, as much as our quarantine regulations and inspection services have improved, world transportation has improved even more - both in coverage and in speed; on land, on the sea, and in the air. The opportunities for and places from which foreign diseases might be introduced are more abundant now than ever before. I should think, therefore, that sooner or later we must expect other foreign diseases to appear on our shores. Let us hope that if they must come in, their presence will be detected early and they can be eradicated soon thereafter.

If we concede that our protection through enactment and enforcement of quarantine regulations is more effective on paper than it can possibly be in practice, and that eventually there will be other leaks in the dike, then we should prepare for that eventuality right now and begin to strengthen our second line of defense. And just what is the best second line of defense? I would say, and I feel confident that you will all agree, that we must learn all we possibly can about the identity and behavior of those organisms in all parts of the world now causing or potentially capable of causing disease on trees of the same or closely related to those species native to North America. Perhaps we should concentrate our efforts in those countries geographically closest and climatically most similar to ours, but I purposely included the whole world in my previous sentence. Even in such remote and tropical places as Africa, Asia, and Indonesia there are combinations of latitude and altitude that create climatic islands not too different ecologically from many places in North America and in them are found tree species very similar to some of our own. Is it at all unreasonable to expect that these "islands" could harbor diseases that would be serious if introduced into our countries? I think not, but I do think there could well be a tendency to relax our guard because they are so far away and off-hand seem so very different.

A considerable amount of preliminary work has already been done over the years toward bolstering this second line of defense and activity is constantly gaining momentum. Foresters and pathologists from North America have been traveling abroad, especially to Europe, for years to observe forestry practices in general and forest disease problems in particular. Dr. J. S. Boyce has been one of our leading observers abroad and he has only recently returned from a globe-circling tour. Dr. A. J. Riker from the University of Wisconsin, is even now on a similar sojourn. Europe has been a particularly fruitful field for the detection of threatening forest tree diseases because of climatic similarities and the many plantings there, some quite old, of trees introduced right from our own back yards. Thus we have gained insight not only to the identity of organisms to be on the watch for, but also have had the benefit of the experience of others in how best to cope with them. We have already been alerted to the potential seriousness of 5 or 6 diseases not uncommon today in one European country or another but not yet known in North America:

An ash gall caused by *Bacterium savastanoi fraxini*
A bacterial canker of poplar caused by *Pseudomonas rimaefaciens*
The watermark disease of willows caused by *Bacterium salisis*
Another mistletoe for hardwoods, especially black locust, namely *Viscum album*
And *Peridermium pini* on hard pines

And while *Fomes annosus* (*Trametes radiciperda*) is probably common property, we should be able to profit from the years of experience our European counterparts have had with this root rot - especially in plantations, thinned stands, and unnatural mixtures.

These foreign travels have generally been arranged on a personal basis and have not been part of a planned, organized, and coordinated international survey effort. The picture is much brighter right now, however, because of two recent events that give us means to at least start a worldwide forest disease survey of the scope we would all like to see.

The first of these is the accelerated activity of the International Union of Forest Research Organizations. While IUFRO was founded in 1890; reorganized in 1929, and again in 1948, it was not until 1956 that the U. S. Forest Service formally joined the organization. At that time Dr. V. L. Harper, Assistant Chief for Research, was elected member of the Permanent Committee, or governing body. One of the aims of IUFRO is the establishment of close personal relations between forest research workers of all countries, especially between specialists working in the same fields of activity. IUFRO works closely with the Food and Agriculture Organization of the United Nations (F.A.O.), with the United Nations Educational, Scientific, and Cultural Organization (UNESCO), with other international organizations, and counts some 100 individuals or organizations from 34 countries among its members.

Of more direct interest to our profession and to the problem under discussion, is Section 24 of the IUFRO program which encompasses Forest Protection. At the Oxford meeting in 1956, Dr. J. R. Hansbrough, Director, Division of Forest Disease Research, U. S. Forest Service, was elected chairman of a new working group on "International Cooperation for the Establishment of Test Plantings of Important Forest Tree Species on Several Continents with Regard to Resistance to Disease and Pests." Membership in Dr. Hansbrough's cosmopolitan committee reads like a "Who's Who" of international forest pathologists:

Mr. Peace of England
Dr. Van Vloten of the Netherlands
Prof. Lohwag of Austria
Mr. Roll-Hansen of Norway
Dr. Krstic of Yugoslavia
Dr. Bakshi of India
Dr. Biraghi of Italy
Prof. Takahashi of Japan
Dr. Boyce of USA
Dr. Riker of USA
Dr. Nordin of Canada

Efforts are also being made to bring in an interested and qualified representative from the USSR.

Through conference and correspondence this committee has agreed upon the following program to meet their stated objectives:

1. Literature reviews and publications along lines similar to Spaulding's Handbooks 100 and 139.

2. Establishment of test plantings and inoculation trials - especially of pines, oaks, and poplars.

3. Special forest disease field surveys.

4. International plantings for determination of disease hazards and disease susceptibility.

Obviously the committee has proposed a worthy and ambitious program, a program that will go far to ease the problems created by the possible spread of forest tree diseases from one continent to another - IF IT CAN BE CARRIED OUT! The committee members are all highly competent and most enthusiastic but each is faced with the problem so common to us all - inadequate finances.

Right here is where the second fortuitous circumstance comes into play, a circumstance that bids fair to at least partially solve some of the fiscal problems and permit at least a start being made toward implementing this needed program.

You are all probably familiar with the fact that the United States Government sells "excess" agricultural commodities to many less fortunate countries in many parts of the world. Payment for these commodities is accepted in currency of the recipient country. Since zlotys, rupees, rupiahs, kyats, bahts, pesos, pesetas, and the like are generally not too useful to us, as such, we have accumulated a considerable credit balance in these countries. Our Congress has recently passed legislation authorizing expenditure of part of these accumulated foreign currencies to support research in the general field of agriculture. Under the provisions of certain sections of Public Law 480 these funds can be used to make grants or negotiate contracts (generally for 5-year periods) with local nationals to undertake research on problems of mutual interest. Certainly the problems of the threat of international spread of forest tree diseases are of mutual concern and well within the realm of agricultural research.

Among the very first suggestions that were sent to various countries as guides to areas of research in which we would like to receive proposals were items on forest disease surveys and the establishment of test plantings. Firm proposals have already been received and approved for a disease survey of Abies pinsapo in the mountains of Spain and for the establishment in Poland of test plantings of forest trees of 5 important North American genera. The first draft of a proposal has also been submitted from Uruguay for the establishment of test plantings of selected North American pines. This proposal is now being reviewed and we are confident that still others will be received just as soon as formal procedural guidelines are more firmly established. We are fortunate again in that our specific interests are receiving the personal attention of Dr. Hansbrough, who is in Europe now as a member of the team negotiating P. L. 480 contracts and making additional surveys of forestry research potential in Poland, Yugoslavia, Finland, Spain, Israel, and France. We have also let it be known in Turkey, India, Iran, and Brazil, that we would view with favor project proposals having to do with either forest disease surveys or the establishment of test plantings. Additional suggestions for similar proposals will no doubt be offered as still other countries, representative of other geographical areas of the world, become active participants in the P. L. 480 program.

It is not presumed that the efforts of the IUFRO group, implemented or assisted wherever possible by P. L. 480 funds, will provide us with all the information we should or would like to have about the world-wide forest tree disease situation. I think it can safely be presumed, however, that the increased knowledge so gained will place us in a far better position than we are now - at least we will be better fore-warned about potential threats. A truly international detective force will be looking after our mutual interests.

Another section of P. L. 480 provides for the translation into English of research publications not now available to most of us because of language barriers. This alone could vastly improve our knowledge of the world forest tree disease situation and serve to keep us more alert to threatening situations. But neither translations, foreign literature reviews, field surveys, nor intercontinental test plantings will keep foreign disease off our shores. We must still depend upon our quarantine regulations and inspections to do this and hence we must work with and cooperate with the agencies and persons assigned the enforcement responsibilities in every way we can. And finally, I would remind you that this is a dual responsibility - to protect ourselves and also to be positive that we as individuals or as agency representatives are not a party to any action that might lead to the introduction of one of our native diseases into some other country. This is truly one situation where "Share and share alike" is not the accepted philosophy!

THE MOLDS OF FOREST TREE SEED

Keith R. Shea

Rehabilitation of harvested forest lands by direct seeding or planting has become a major endeavor of foresters of the Weyerhaeuser Company. The objectives include regeneration of these lands immediately after cutting to assure continuous productivity. Such objectives are dependent on an adequate supply of desirable tree seed. To meet this need, cone collection and seed processing have become an integral part of our forest practices. Along with foresters, pathology, soils, physiology, regeneration, silviculture, entomology, and wildlife biology are represented in coordinated research on aspects of seed procurement and regeneration. The purpose of the present paper is to discuss one aspect of the pathological problems involved, viz., the fungi (commonly called molds) on forest tree seed, especially Douglas-fir.

Examination of the cones in sack storage revealed numerous fungi not only on the cone surfaces but between the scales and on the wings and seed coat of the seed. By the fall of 1957, sufficient evidence had been found to suggest that the molds might be the cause of unexplained losses in seed viability during storage of the cones prior to processing. As a result, research was initiated with the initial objectives of developing methods for assay of the molds and for determining losses.

Review of Literature

A review of pertinent literature (Shea, 1957) showed that little attention has been given to fungi associated with forest tree seed prior to sowing. Few seed-borne diseases of trees are known (Noble et al, 1958) and many of these are not well substantiated or have received little attention. Shea (1955) suggested that the indiscriminate introduction of seed and pollen from other countries was accompanied by the danger of introducing tree pathogens. The molds of Douglas-fir seed were studied by Salisbury (1953, 1955) who found no clear correlation between high mold count and low viability of extracted seed. The most common molds found were species of *Penicillium*, *Mucor*, *Aspergillus* and Pullularia. Most literature dealt with the molds associated with stored grains. It is these reports which provide background for investigations on molds associated with forest tree seed. A most complete and comprehensive review of the literature on deterioration of stored grain by fungi has been published by Christensen (1957) who with his co-workers is responsible for much that is known on this subject. It was noted in his review article that deterioration of stored grain is manifested by decrease in germination, decrease in processing quality, "sick" or germ-damaged grain, heating, and mustiness. Over 50 fungi which appear to be involved (Schmidt, 1955) may be divided into two groups, viz., field fungi and storage fungi (Christensen, 1957). Species of Alternaria, Helminthosporium, Fusarium, Cladosporium, Diplodia, Chaetomium, Rhizopus, and Absidia are included in field fungi, whereas Aspergillus and Penicillum are the principal genera of storage fungi. Tuite and Christensen (1955, 1957) found that harmful fungi increased greatly between harvest and arrival of grain at terminals. Invasion of seed by storage fungi impaired storability, whereas, field fungi appeared to be of little consequence.

Media for isolating the fungi of grain have received considerable attention. Christensen (1957) has found that no one medium or technique is suitable for determining all organisms that may be present in a given lot of seed. The principal medium used is malt salt agar consisting of 1 to 2 per cent malt extract, 2 per cent agar, and 7.5 to 20 per cent sodium chloride. For special purposes, Czapek-Dox agar containing 40 to 80 per cent sucrose is recommended.

To determine fungi associated with grain, whole or macerated seed are used (Christensen, 1957). Whole seed may be surface disinfected in 1 per cent sodium hypochlorite and rinsed in 7.5 per cent solution of sodium chloride or the seed may be washed in a jet stream of water before plating. When it is desirable to determine the number of viable fungus spores present, a given weight of seed is comminuted in a blender with a sterile solution of 0.2 per cent agar and 7.5 per cent sodium chloride. Dilutions are made in solutions of the same composition until the desired dilution is obtained. One ml. aliquots of the dilution are placed in petri dishes, the selected medium added, swirled, allowed to harden, and the dishes incubated. Counts of the mold colonies are made and the results expressed in colonies per gram of seed. Fungi selected for isolation and study usually are transferred to other media. Identification of species of Aspergillus and Penicillium is based on their cultural characteristics on Czapek-Dox medium (Thom and Raper, 1945; Raper and Thom, 1949).

The invasion of stored grain by fungi is influenced by a complex of conditions which in practice operate together (Christensen, 1957). Moisture content, temperature, amount of previous infection, time, and the activities of grain-inhabiting insects and mites are the major ones. It appears that seed moisture contents below 12 per cent are relatively safe provided no portion of the seed in storage is much above this level. Most fungi which invade stored grain grow best at about 30° C. A few will grow at 55° C. and others as low as 5° C. Time is associated intimately with moisture content and temperature. Thus, within the limits of growth of the fungi, the higher the moisture content and temperature the shorter the time seed may be stored without adverse effects. Apparently insect invasion of stored grain results in increased moisture content favoring mold development. Also, insects may act as vectors.

Control of molds of stored grain involves three general methods (Christensen, 1957). They include treatment with fungicides, storage under toxic or inert gases, and drying the grain to reduce moisture content to a safe level. Fungicides are most effective only so long as free water is available, a point which limits their use in grain storage, but may not be critical with moist, green forest tree cones stored for shorter periods. Storage under gases has practical limitations which limit their usefulness. Effective long-time storage of grain may best be effected by obtaining a moisture content sufficiently low to inhibit invasion by storage fungi. Christensen (1957) noted, however, that wheat seed stored outside in bags but protected from direct rain and snow picked up sufficient moisture from the air to raise the moisture content to 15 per cent at which level storage fungi flourish.

Deterioration of Forest Tree Seed

Deterioration of tree seed by fungi involves problems of similar nature but differing in many respects from those of grain. For example, forest tree seed are exposed to many conditions before storage which permit the development of mold fungi. The cones are collected, placed in burlap sacks, and stored at collecting points or processing plants for indeterminate periods prior to seed extraction. After extraction, the seed are dried and stored for varied periods until used in field or nursery seeding.

Investigations of the molds of forest tree seed involve the development of methods and techniques unique to forest tree seed procurement. It is essential to determine the etiology and epidemiology of seed deterioration. Before control methods can be justified, the losses attributable to molds must be assessed. Initial studies at the Forestry Research Center have shown that methods developed by Christensen and his co-workers (Christensen, 1957) are suitable for most purposes. It now is common practice to use 7.5 per cent salt, 2.0 per cent malt extract agar for routine analyses. Studies have shown that certain molds from tree seed can develop on malt extract agar containing as high as 15 per cent salt and on Czapek-Dox agar with 80 per cent sucrose added. However, most consistent results yielding the greatest number of molds are obtained with 7.5 per cent salt in malt extract agar. For some special studies ordinary malt extract agar, Czapek-Dox agar, and potato dextrose agar are used without addition of salt or sucrose.

Over 40 isolates of fungi have been obtained from Douglas-fir seed in our laboratories. The most common fungi include species of *Penicillium* and *Aspergillus*. Members of the *Aspergillus niger* and *A. flavus* groups and the *Penicillium oxalicum* series are common isolates. Other fungi include species of *Rhizopus*, *Thamnidium*, *Pullularia*, *Trichoderma* and *Trichothecium*, to name a few. Additional fungi are now being identified. Most of the above fungi are capable of at least limited development on malt extract agar containing 7.5 per cent salt. It must be recognized that an individual medium may be selective. Therefore, several media must be used to determine the range of microflora present.

Development of molds in cones and on seed apparently begins on the tree. However, examination of fresh cones commonly reveals no mycelium on the cone surfaces. Norman Johnson, our entomologist, who has studied the insects of Douglas-fir cones has noted the development of fungi in the galleries of cone and seed insects. Often, the areas adjacent to the gallery are necrotic and invaded by fungi. Whether these are saprophytic fungi attacking tissues killed by insect activity or parasitic is open to question. Currently, we do not know the effect the fungi associated with insect damage may have on seed. However, it appears that additional damage to the cone and seed is the direct result of fungus attack arising from infection courts provided by insect activity. Whether there are two distinct groups of organisms, the field and storage fungi, as with grain is open to question. There are, however, increased numbers of Aspergillus and Penicillium species in relation to other fungi associated with seed as cone storage time increases. Numerous other fungi also appear to be involved with the various stages during cone procurement and processing.

Douglas-fir cones collected and stored in burlap sacks may become covered with mold fungi. Co-ordinated experiments with Dr. Rediske, our physiologist, on after-ripening of seed in Douglas-fir cones have shown that the fungi are associated with decreased viability of seed from cones stored for varied periods. As viability decreased, mold counts increased. Cones dipped in fungicides before storage yielded seed of greater viability over longer periods than did seed from untreated check cones. Later in the season when seed were mature and cones more ripe, losses were less and the causes more poorly defined. Additional studies are being continued with the most promising fungicides to determine their effectiveness for control of molds. Fungicides for testing were selected for their fungistatic properties in vitro using the more common mold isolates as assay organisms.

Mold growth and yield of viable seed are affected markedly by the conditions under which cones are stored. Apparently 3 factors, moisture, temperature, and time of storage, are involved. Cones stored under adverse environmental conditions are subject to heating as a result of biological activity. Examination of seed from such cones has shown that molds decreased potential yields markedly. Seed in all stages of deterioration were found. In extreme instances, fungi had invaded the seed coat and were observed fruiting on the deteriorating endosperm. The most common fungus found was Pullularia pullulans. To date, all evidence points to fungi as a major cause of reduced seed viability in stored cones. Research is underway to determine practical methods for preventing such losses attributable to fungi.

Extracted forest tree seed may be stored for prolonged periods before utilization in the field or nursery. Barton (1954) has shown that Douglas-fir seed retained full viability for three years when stored at 18° C. and 5.8 or 13.6 per cent moisture content. When seed were stored at similar moisture levels, and at 5° C., marked deterioration resulted after 12 months at 13.6 moisture content. Christensen (1957) has shown that storage molds of grain are capable of attacking seed at this temperature and moisture content.

Perhaps, part of the loss in viability found by Barton could be attributed to fungi. In most instances, however, forest tree seed are stored at temperatures and moisture contents which prevent mold growth. Consequently, any reduction in viability of extracted seed must occur before seed is stored or after storage when environmental conditions are favorable for fungus development. Our experiments have shown that molds on tree seed retain viability for at least 12 months when seed are stored at -12° C. and approximately 8 per cent moisture content. During this time no reduction in germination was noted. However, seed were well inoculated and needed only favorable conditions for continued mold development on and in seed.

Molds associated with seed may have adverse effects on seed in the field. Gibson (1957) in Africa has reported that loss of Pinus patula seed associated with damage to the seed coat was due to invasion by normally saprophytic seed-borne fungi. The destruction of the seedling appeared to depend largely on its growth rate since it became more resistant as germination progressed. He suggested that fungal invasion of seed was facilitated by minute damage incurred during mechanical dewinging. Laboratory studies with 18 of the common fungi we have isolated have shown that all were capable of destroying seedlings under conditions favorable to mold development.

Thus, it seems likely that the molds prevalent on tree seed may contribute to seed decay and pre-emergence damping-off in the field. A field study with radio-tagged seed by Lawrence (1959) on the Wynoochee Tree Farm in western Washington has shown that seed decay and damping-off were major causes of seed loss. Deterioration of the seed and damping-off may result from direct attack by seed-borne fungi or from general depletion of vigor predisposing the seed to other fungi in the soil. This theory is borne out by the report of Noble, et al, (1958) who in their list of seed-borne diseases have reported that Apergillus niger and other Aspergillus spp. attack seed of a number of plants in soil. Penicillium oxalicum and other Penicillium spp. are known to cause seed rot of sorghum and corn. Likewise Rhizopus spp. cause loss of cotton seed and seedlings, as well as sorghum and corn. Koehler and Holbert (1930) have shown that Aspergillus, Rhizopus, and Penicillium invade the scutellum and adjacent embryo of corn in the soil damaging and weakening the endosperm. The similarities to fungal invasion of Douglas-fir seed are so striking as to leave little doubt that comparable events would occur. Accordingly, research is being planned to explore more fully damping-off and seed decay in the field and the role of seed-borne fungi in the damping-off complex.

Future Needs

It has been established that the molds of forest tree seed can cause reduction in yield and viability. Evidence suggests that the effects of molds may carry over into the field and contribute to seed decay and damping-off. The question arises as to what lines of approach future research should take.

The prevalence of a wide variety of molds and the classes into which they fall suggest three possible groupings. Certain molds may be wholly saprophytic and contribute little, if anything, to the damage of seed. Others may actually be beneficial in that they are antagonistic to the third class, the harmful fungi. With such possibilities, it seems that the etiology of seed deterioration should be explored more fully and the causal agents isolated. If fungi antagonistic to damaging molds are found, it might be possible to encourage their growth at the expense of the harmful fungi.

Once the causal agents are well-defined, it is essential to determine the epidemiology of seed deterioration. Studies on the effects of those factors in the environment which contribute to the development of mold fungi could provide bases for devising control measures. Of special concern are temperature, moisture content, relative humidity, time of exposure to these predisposing factors, and the environmental conditions in the field. These are challenging subjects for joint investigation by pathologists, physiologists, soils specialists, and forest regeneration experts.

Sound control measures should be based on thorough investigations of the etiology and epidemiology of seed deterioration. Control measures must be divided into two parts. The first involves control of damage to seed in the cone prior to processing. The second involves the seed in the field after seeding. Reducing the severity of seed contamination and infection in the cone and processing stages may alleviate damage in the field. Thus, it appears inevitable that the two phases of control be investigated jointly. Mold control in the cone may be attempted through chemicals, by creating conditions unfavorable for development of damaging fungi, or encouragement of fungi antagonistic to the harmful ones. In the field, the addition of fungicides to standardized seed treatments appears most promising. Any chemical additive should, however, be assayed for phytotoxicity and compatibility with rodenticides or other seed treatments. Even differences in the phytotoxicity of different formulations of the same chemical have been noted (Shea, 1959).

In conclusion, the evidence indicates that considerable savings can be accomplished by alleviating damage to tree seed attributable to molds. Yields of viable seed can be increased thus reducing costs and extending the acreage of harvested forest land which can be seeded. By increasing the survival of germinable seed in the field, seeding rates can be reduced with the expectation of adequate stocking. The problems associated with seed procurement and regeneration cut across many fields of specialization of which forest pathology is a part. Most effective rehabilitation of forest lands can be accomplished only when the varied specialities are coordinated in a common endeavor.

Summary

Rehabilitation of harvested forest lands by planting or seeding has

become a major endeavor of forest managers of the Weyerhaeuser Company. Among the disease problems encountered are the molds on seed.

Research on the molds of tree seed was begun in 1957 when techniques for study of molds were developed. Experiments to date have shown that the molds cause reduction in viability and yield of Douglas-fir seed during storage of cones prior to processing. The molds remain in a viable condition on seed during cold storage previous to sowing. Evidence strongly suggests that these seed-borne fungi contribute to seed decay and damping-off in the field. Research on the etiology and epidemiology of seed deterioration is being continued so that practical control measures can be developed. Plans are to extend the research and investigate the causes of seed decay and damping-off in the field.

Future needs include additional knowledge of etiology and the epidemiology of seed deterioration. The possibility of control by fungi antagonistic to harmful ones is worthy of consideration along with control based on creating environmental conditions unfavorable for mold development and/or the use of chemicals.

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A STUDY OF THE FACTORS AFFECTING THE DEVELOPMENT OF MYCORRHIZAE ON DOUGLAS FIR SEEDLINGS

Ernest Wright

A paper by Linneman (2) appears to be the most complete published report to date on the mycorrhizae of Douglas fir (Pseudotsuga menziesii (Mirb.) Franco) seedlings. Further information is available in an unpublished report by McMinn (3) of Canada for older trees. Pentland discussed the results of her studies at the 1958 Forest Disease Work Conference. Extensive studies by Wright and Tarrant (4) have been made on the occurrence of ectotrophic mycorrhizae on Douglas fir seedlings growing on recently burned-over areas in western Oregon and Washington. More detailed information is needed, however, on the factors affecting the development of mycorrhizae on young Douglas fir seedlings in reforestation and afforestation programs.

It is well known that Douglas fir is an intolerant species; and it has been shown by Isaac (1), as well as by others, that direct sunlight results in considerable heat injury and very poor survival of Douglas fir reproduction. For those seedlings which survive, as well as those that have not been injured, information is needed on the effect of light intensity on the development of mycorrhizae and subsequent seedling survival.

To obtain this information, a series of tests were made by the Oregon Forest Research Center. It was found that under a natural forest canopy in second growth stands with good moisture conditions, three-month-old Douglas fir seedlings received a minimum light intensity of 200 foot candle power which resulted in restricted development of lateral roots. Seedling survival, of course, was very poor and no ectotrophic mycorrhizae were formed. For the same age seedlings grown in a clearing under satisfactory moisture conditions and receiving an optimum of 6000 foot candle power illumination, lateral rootlets were well developed and ectotrophic mycorrhizae were abundant. Such ectotrophic mycorrhizae are gray to black in color and digitate in form, Figure 1. By the end of the second growing season racemose mycorrhizae had become abundant and the digit-type less so, Figure 2. Racemose mycorrhizae are most common at a depth of 80 to 100 mm while the digit-type are commonly both shallower and deeper. Mycorrhizae rarely occur shallower than 20 mm or deeper than 200 mm.

Inoculation tests so far have not positively established the identity of early ectotrophic mycorrhizal formers but tentative identification indicates that Cenococcum graniforme(Sow.) Ferd et Winge. is one of the most common mycorrhizal fungi found on the roots of Douglas fir seedlings. All black mycorrhizae, however, are not C. graniforme and many are the Dn. type of Bjorkman, otherwise known as (Mycelium radicis atrovirens) and are generally epiphytic or perhaps sometimes parasitic.

This study has been extended to the formation of ectotrophic mycorrhizae on one-year-old Douglas fir seedlings growing in mineral soil and the effect of a two-inch layer of sawdust, forest litter or charcoal mulch. There were fewer but deeper occurring mycorrhizae on the seedlings grown in full sunlight (8000 ft. candle power illumination) both with and without mulches than on the seedlings which grew under 1/4 shade (6000) foot candle power maximum light intensity). Surface soil temperatures as high as 70° C. occurred in unshaded mineral soil without mulch. This tended to inhibit mycorrhizal formation at normal depths and the depth of mycorrhizae was much greater on the seedlings grown in full sunlight. The fewest mycorrhizae occurred on seedlings grown in 3/4 shade with or without the benefit of mulches, Table 1 and Figure 3. This information is particularly interesting since in previous studies it was observed that for one-year-old Douglas fir seedlings, the initial depth of mycorrhizae was related to severity of burn. (5).

In all these observations, it has been noted that there is considerable variations in the number and the occurrence of ectotrophic mycorrhizae on one-year-old seedlings grown under the same conditions. This may be due to genetical variation within the Douglas fir species, a point which needs further study. On two-year-old seedlings differences in number of mycorrhizae become less pronounced and the genetic trend is less apparent.

These studies are being continued since more information based on pure cultural inoculations is needed not only as to the most common fungi-forming ectotrophic mycorrhizae on Douglas fir seedlings, but also to more exactly determine the influence of light and soil temperature on the development of ectotrophic mycorrhizae under natural conditions.

Effect of Light on Mycorrhizal Development and Growth of 1-0 Douglas fir

Light	Mycorrhizae	Mycorrhizal depth	Seedling height	Root length
	No.	Mm	Mm	Mm
No shade	13.3	99.2	62.8	163.6
1/4 shade	16.1	62.1	58.8	162.5
3/4 shade	11.7	84.0	60.8	156.5

Data taken from seedlings from Richard Hermann's Marys Peak Plots.

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PHYTOPHTHORA ROOT ROT OF NORTHWEST CONIFERS IN RELATION TO FOREST MANAGEMENT

Lewis F. Roth

I have been asked to discuss the fungus genus Phytophthora as a forest pathogen and to consider such forest management relationships that may exist in connection with diseases these fungi cause. My remarks arise from experience with Phytophthora as we know it in Oregon where information is completely lacking on management procedures applicable to infected stands (9, 11, 12, 13). However, I shall draw upon the far better known little leaf disease of south-eastern United States for information that may aid in the evaluation and understanding of our western problem. At least 2 excellent papers have appeared dealing with management of little leaf infected stands (2, 3).

No fungus name rings more clearly on the ear of the plant pathologist than the name Phytophthora. However, a number of us were not trained in the plant pathology tradition, and some probably have forgotten the details of this fungus that first ravaged the potato fields of the northern hemisphere at the middle of the past century. Moreover, the genus has grown considerably and rather off-center from the original botanical type. It might be well, therefore, briefly to refresh ourselves on the nature of this genus and a bit of its history.

In general Phytophthora species develop in moist situations where host infection appears to depend on free-swimming spores. They are sometimes regarded as "water molds", a group to which they are allied but from which I feel they differ in their apparent demand for association with tissues of a living plant for vegetative growth and for survival. No Phytophthora species were originally obtained from a soil source rather than a plant source and frequently they are difficult to recover from the soil after introduction. On the other hand, soil has been a fruitful source of new species of the sister genus Pythium. Phytophthora species do form resistant oospores that apparently can survive in the soil away from the host for extended periods. Too little is known of the behavior of these spores.

Spread of the different Phytophthora species probably is most effectively accomplished through movement of infested soil and by free swimming spores in flowing or impounded water. In some species the sporangia, which produce the swimming spores, are born at the surface of the substrate and are detachable. These sporangia may be carried by the wind to germinate in a drop of water some distance away. In general, the details of infection are poorly known but most infections appear to result from zoospores.

The potato fungus originally described in France in 1845 by Montagne as Botrytis infestans was transferred by de Bary in 1876 to become the type of his new genus Phytophthora. Three years later, in 1879, the second species P. fagi was added to the genus by Hartig in Germany (15). It is noteworthy that this was a parasite on beech seedlings. Across the years species have been added until there are now approximately 68.

One seldom sees a fungus genus attacking a wider group of host plants on a wider geographic basis. All the continents are represented in the original descriptions and most of the major land masses. It is interesting to note that in the original descriptions nearly half were in one way or another associated with trees. This strong representation of tree hosts of course only suggests the potential range of woody plants liable to attack. While some species are limited to a single host others may attack many. _Phytophthora cinnamomi_, for example, has been found on more than 100 woody host species since its original description on the cinnamon tree (13).

It is also interesting to note that while the early descriptions were from western Europe where mycological exploration and pathological research were actively developing, it was not long until the areas of accumulation of new species shifted to warmer, more exotic areas (15) even though in these areas fungus exploration and applied pathology were, for the most part, not advanced - from Formosa 13 species; from Japan 9; from the East Indies 6; from India 5. One cannot but wonder when studying some of our Phytophthora problems, if the species involved might not well have been described earlier elsewhere. _P. cinnamomi_, was of course first described in Sumatra.

Phytophthora has not made great inroads into the world's coniferous forests, and there are some grounds for thinking that it may not. On the other hand, it has demonstrated real capacity as a forest pathogen and has created apprehension which, along with actual losses, justifies investigation (9, 2).

The phytophthora related disease of shortleaf pine in southeastern United States known as littleleaf is familiar to you, I am sure (2, 3). From my comments at previous conferences many of you know of our experience in Oregon with _P. lateralis_ on white cedar, _Chamaecyparis lawsoniana_. Less familiar may be the destructive activity of _P. cinnamomi_ and _P. cactorum_ in the _Pinus radiata_ and _Chamaecyparis lawsoniana_ shelter belts and forests of New Zealand and the killing of Douglas-fir by _P. cinnamomi_ in plantations in Portugal (7, 8).

A brief review of these diseases may provide background for discussion.

Littleleaf (2) typically occurs in short leaf pine stands 30-50 years old primarily where these stands occupy eroded sites abandoned from agriculture which are low in fertility and have poor internal drainage. The disease appeared first rather widely scattered over the piedmont area in the mid-1930's. However, these first reports of the disease appear to follow by some years the arrival of the associated _P. cinnamomi_ in the area.

A somewhat parallel situation occurs with _Pinus radiata_ in New Zealand. According to the first report the outbreak occurred rather generally over a wide area and was on agricultural land (7). To be sure land use in New Zealand has differed widely from land use in our southern states. The parasitism of _P. cinnamomi_ on _Pinus radiata_ in New Zealand is much more severe than in the little-leaf disease of _Pinus echinata_. The New Zealand outbreak occurs in a planted, highly artificial forest situation and the causal fungus probably is of foreign origin.

Destruction of white cedar in Washington and Oregon appeared first in nursery and ornamental plantings in the vicinity of Seattle and Portland (5). At that time damage did not occur in the native cedar range or apparently elsewhere in western Oregon where ornamental cedars were widely grown and had become a lead item in the commercial nursery trade. The disease spread rapidly, however, and within two decades nurserymen in western Oregon could no longer grow the valuable ornamental cedar varieties with any confidence of success (12). In 1942 the fungus, which had been isolated a few years earlier, was described as a new species, P. lateralis (14). In 1952, about 30 years after first observation of the disease in the Seattle area, it appeared in the Coos Bay urban area deep in the native cedar range (9). From there it spread within 2 years about 75 miles along the coast, most of the length of the range of commercial cedar. The distribution pattern constitutes a network along the streams and estuaries of the bay, along the highways, railroads and country roads, along rural stockways and wherever earthmoving construction is in progress. Penetration into the coast mountains is slower, but most observers feel that it is only a matter of time until the fungus will pervade the entire cedar range. There seem to be no strong limiting factors or barriers.

P. cinnamomi, which has a host range of over 100 trees and shrubs, rapidly is becoming a cosmopolitan fungus. As we have stated, it is involved in the littleleaf problem in southeastern United States. It is involved in agressive damage to Pinus radiata in New Zealand and has shown its pathogenicity to Douglas-fir. Our first record of this fungus in Oregon was in 1950 and since that time it has followed a pattern of spread and increase in the commercial nursery trade and landscape plantings just like that of P. lateralis a decade or two earlier (11, 12). Is it to follow the path of P. lateralis into our commercial fir forests?

Why do these Phytophthora diseasesappear to confront us at this time? Are they native or have they been introduced? In Oregon our industrial supporters have been conservative in attacking Phytophthora cinnamomi, perhaps partly in the hope that it is a native fungus and accordingly not a great threat. With the assistance of industry and public agency cooperators we have recently surveyed forest soils of 8 counties regarded as most probable habitats and found no Phytophthora. Along this same line Dr. George Zentmeyer has sought the fungus in wild lands of Mexico and Central America and has not found it.*

While Phytophthora cinnamomi, recognized in this country for the first time in 1930 (4), is widespread and persistant in forest lands of southeastern United States this probably was not always the case. The outbreak of littleleaf appears long to have been preceded by destruction of the very susceptible native chestnut. Damage to the chestnut has been described as a "recession" (4) and a reduction of range (1) which may have begun before 1824, the time of first observation of chestnut mortality in southern Georgia (6). Damage then moved northward in a wave to meet ultimately its climatic or edaphic limit or to join with the southward moving Endothia blight.

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* Personal communication.

Crandall (4) states, "The history of Phytophthora cinnamomi as we have been able to reconstruct it indicates that the fungus probably came to the United States more than a hundred years ago, possibly by way of trading ships operating between our southern ports and the East Indies or Asia. The importation of numerous exotic plants for the gardens of antebellum estates could easily have been the direct means of its entry".

I see our experience with Phytophthora lateralis as a contemporary version of the chestnut story and feel that the original home of the parasite will some day be found in eastern Asia.

To me there seems little doubt that these Phytophthora diseases of forest species are caused by introduced pests. We must regard them as such and, because we know from experience that they may be loaded with potential danger, they should be dealt with wisely and effectively. How should we proceed?

The need for a research program adequate to evaluate the threat of these fungi and to provide a basis for control if needed is self evident.

In the case of white cedar root rot, real interest, willing effort and a moderate financial outlay probably could protect the mountain stands of Port Orford cedar for a long time to come. Such action seems improbable inasmuch as Port Orford cedar is not now regarded as a premium forest species. The sites it occupies can produce Douglas-fir or Sitka spruce and Western Hemlock of high quality. The fact that protective measures at best would prove a nuisance to the harvest of more numerous and valuable species increases the improbability of action. If the wild species is destroyed its replacement in forestry by resistant varieties is most unlikely even if resistant stock were obtainable. However, if such disease resistant root stock could be found it would be a boon to the nursery industry.

Far greater values are at stake where P. cinnamomi on Douglas-fir is involved. Knowledge of the extent to which forests of the Douglas-fir region are threatened is the provoking uncertainty and the critical problem is to know our needs for holding action while the threat is being evaluated. There appears to be no way of destroying the fungus at its present points of infection, so that measures to limit spread appear logical.

I see no place at the present time where the forest manager can contribute to control through usual forestry practices. However, some precautions might be considered. For example, in the warmer, wetter parts of the Douglas-fir region it would be well to avoid the use on forest roads of river rock which is liable to contamination. Also to be avoided is the use without adequate cleaning of earth moving equipment in the valley where contamination is liable followed by use in the woods. Also of this nature is the parking of logging trucks in residential or other areas liable to harbor Phytophthora.

However, positive action is needed nearer the known sources of the fungus. We are not certain of the extent to which the fungus has spread from infested nurseries, nor are we sure of its capacity for spread under our conditions. Its ability to survive in our undisturbed soils is still not settled. The fungus certainly has not shown the capacity of P. lateralis in these respects, and at the present time a rigid embargo of plant materials seems to be regarded as not justified.

Foresters should recognize that this disease constitutes a threat to the nurserymen, possibly even a more serious one than to the forester. The damage to azalea, camelia, heather, rhododendron, and the ornamental evergreens strikes at the very heart of the industry.

Our State Departments of Agriculture can advise as to which nurseries are infested. They cannot, however, restrict the movement from these nurseries of healthy or asymptomatic stock carrying infested soil. Nor can they compensate the grower for stock condemned for cause. There appears to be an opportunity here for foresters and nurserymen to approach jointly the problem of spread in a truly cooperative spirit and to work out a realistic approach to the suppression of movement of this pest from the nursery source or among the nurseries. In the final analysis this would prove of great worth to both industries.

Control of these diseases by chemical means holds some promise and should be actively investigated. Perhaps promise of chemical control is to be found in the field of systemic protection as well as in the area of soil disinfection which for some time has received most active study.

The possibility of developing inherent resistance also merits study, even though the outlook for white cedar, as stated earlier, is poor. Our experience with P. cinnamomi on northwest species has been so brief that it is difficult even to speculate on the opportunities. I understand that work is in progress to improve the resistance of shortleaf pine to this fungus.

Success with forest protection from these diseases will depend on detailed knowledge of the pathology of Phytophthora species. This knowlege may never be complete or adequate to provide a basis for control of disease in its severest expression. However, even quite incomplete knowledge may sometimes meet the control requirements if available early enought in the disease situation. This circumstance raises the question of where and when research for forest protection should begin. It would appear that with introduced diseases such as the Phytophthora species attacking northwest conifers, it might well have begun some time ago, perhaps in Eastern Asia. Certainly a maximum amount of information on such diseases prior to the time of their introduction would be a great help to us. In this regard, of course, we must be deeply appreciative of the worthy contributions of hundreds of students of Phytophthora diseases in general who working around the world have provided us with a foundation on which to build.

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GEOGRAPHIC PATTERNS IN GALL-RUST INFESTATION

R. S. Peterson

Western gall rust, Peridermium harknessii Moore, ranges from Mexico and Nebraska to Alaska, and eastward in Canada for an unknown distance. My own field experience with this pathogen extends from southern Colorado and northeastern Utah to northern Idaho.

Even in this smaller area, considerable differences in the behavior of the rust can be observed. Differences in host pathogenicity, amount of infection, time of infection, and development in the host will be considered briefly. A major purpose of my remarks is to invite comments from members of the conference regarding gall-rust infection in other areas.

Host Pathogenicity

Observations in mixed stands of hard pines suggest variation in susceptibility to gall rust both by area and according to host species. For instance, where the rust occurs in mixed lodgepole-ponderosa stands in Colorado, lodgepole is consistently infested much more than is ponderosa. In one such mixed stand in the Black Hills of South Dakota, lodgepole seemed to be attacked only slightly more frequently than ponderosa. Near Superior, Montana, lodgepole and ponderosa appeared to be about equally hard-hit.

As another example, gall rust is found commonly on jack pine in Canada, but this species appeared to be free of rust, or nearly so, in the planting which I examined at Priest River, Idaho, although lodgepole and ponderosa pines only a few yards away were infested. Jack pine in Nebraska plantations was reported to be free of gall rust where nearby ponderosa was diseased.

Thus there is a possibility that the rust in a given area is more virulent on predominant local hosts than on exotics (such as jack pine in Nebraska), even though these exotics are quite susceptible to strains of the rust in their native ranges. Scots pine, however, is among the more favorable hosts in many areas; let us hope that exclusion of gall rust from Europe continues to be successful.

Amount of Infection

Intensity of infection probably varies geographically for all pathogens. Study of this variation can sometimes give clues with regard to natural factors which control disease. In the case of gall rust, the most notable spatial variation is at the local level: 100 per cent of the pines in one stand may bear galls, but only 2 per cent in a stand of the same species a few chains away. Even within an even-aged stand, intensity of attack varies greatly. On the other hand, it is not easy to say for gall rust (as one could for white pine blister rust or Atropellis) that the level of attack in the northern Rockies, for instance, is much higher than that in Colorado. Damaging gall-rust outbreaks are local events; the number and size of these events may not vary significantly by region.

A few correlations of the amount of rust with possible causal factors have been noted. For instance, it is probable that the parts of a stand near openings, or less dense parts of a stand, are more apt to be heavily attacked than are dense or interior parts. In a given year, young stands seem much more apt to be attacked than are old stands, at least in the central Rockies. And it has been suggested repeatedly that the abundance of the Peridermium is related to the abundance of telial hosts. These observations, however, are not yet supported by convincing data, and in any event are not sufficient to explain all local differences in degree of infestation. Microclimatic study appears promising in this regard, coupled with experimental determination of the gall-rust life cycle and physical conditions which favor each stage.

Years of Mass Infection

The geographic extent of a particular epidemic may be surmised by determining the area over which a particular wave year of infection prevails. This is done by dating the origins of rust galls in a large number of plots. The method of dating assumes that infection occurs on first-year twigs--this assumption seems to be correct for at least 90 per cent of the galls. Thus far we have data for some 2300 galls from 19 plots, 8 of them in Roosevelt National Forest in Colorado and the other 11 scattered in South Dakota, Idaho, and Montana.

For example, in a belt transect through 90-year-old lodgepole in Colorado, intensity of infection was variable through the 40 fortieth-acre plots, but galls of 1950 and 1955 origin continued to predominate throughout. In the sample of 583 galls spanning 13 years of origin, 29 per cent of the galls dated from 1955 and 16 per cent from 1950. In a second plot 900 yards from the first, containing only young lodgepole reproduction, 70 per cent of the 514 galls dated from 1955 and 10 per cent from 1950--a repetition of wave years identified in the first stand, though the intensity of infection was much lower in the second stand. Only 13 miles to the south, however, a sample of 267 galls from young lodgepole gave little or no indication of an outbreak in 1950 (2.6 per cent); 1953 (43 per cent) and 1955 (34 per cent) were the wave years. Fifty-four miles further south, still on the Roosevelt Forest, 1950, '53, and '55 all disappear as wave years, to be replaced by 1945, '46, and '51.

In the Boise Forest of southern Idaho, 1952 and 1956 appeared to be wave years, each year appearing in two out of the three gall collections made. Near Grangeville, in central Idaho, only 1957 stood out as a major outbreak year. Substantial infection occurred during 1953, 1956, and 1957 in five of the six samples examined in the Inland Empire, but the relative importance of these years varied from plot to plot, and other years gave rise to significant infection at some stations.

A conclusion to be drawn from these and other, similar data is that

UNITED STATES GOVERNMENT

Memorandum

Department of Agriculture
Forest Service – Region Two
Denver 25, Colorado

R. Peterson

6540
April 27, 1960

To : Forest Supervisors; Director, Rocky Mountain Station; and Division Chiefs

From : Donald E. Clark, Regional Forester, By Neal Rahm

Subject: Payments

The State of Colorado income tax was raised for calendar year 1960. To date we have continued to deduct only 6% of the Federal tax withheld. In practically all cases the present deduction will not cover the Colorado tax that will be due at the end of 1960. This will result in the need to make an estimated return for 1961 and make quarterly payments if the tax due at the end of 1960 is $20 more than was withheld.

To save employees this inconvenience, all major employers are increasing the state tax deduction. A large number of Forest Service employees have requested that we increase our deductions.

Decision has been made to increase the Colorado state withholding deduction from 6% of the Federal tax withheld to 12% effective with Pay Period No. 8, which begins April 17.

Please inform all employees subject to Colorado income tax of this change.

Neal M. Rahm

Distribution: All Employees

climatic conditions favoring gall-rust epidemics are more widespread, in a given year, than are the actual concentrations of gall which result. Only a portion of a stand may suffer a damaging attack, but other stands in the same district, or perhaps in the whole national forest area, will be attacked that same year. This still falls short of the regional epidemics, as in 1937, ascribed to Cronartium ribicola. Gall-rust epidemics seem to be somewhere between "local" and "regional" in scope.

It is hoped that information regarding wave years will lead to knowledge of the rust's life cycle. For instance, in the southwestern Idaho data, the four years of greatest rust infection were precisely the years of greatest June precipitation in that region, but rainfall during July, August, and September of those years was average, less, or lacking according to Weather Bureau records from Cascade, Idaho. Likewise, infection by gall rust near Grangeville, Idaho, and Superior, Montana, was plentiful in 1957 and above normal in 1953, yet these years became exceptionally dry after June in both localities. It seems probable that waves of infection are associated with moist periods. Therefore, infection in the spring is suggested. And it may well be that telia on the supposed alternate hosts are not even formed until mid-summer. This leads us to suggest pine-to-pine infection by aeciospores. On the other hand, some of the rust wave years in Colorado seem to coincide with August precipitation maxima; in August, basidiospores but not aeciospores are abundant.

Development in the Host

To me the most striking and surprising geographic variation in gall-rust behavior involves the pattern of attack on a tree. In the Inland Empire, the ratio of branch galls to trunk cankers caused by P. harknessii on ponderosa and lodgepole pine must be thousands to one, if we exclude seedling infections. A number of pines in the Grangeville area, for instance, were examined carefully: several bore hundreds of galls, and were being killed by loss of branches, but not a single gall in these trees touched the trunks.

In Leaphart's report (1) of a western Montana infestation, no mention is made of trunk cankers. I spent a few hours examining the area involved, and could find only three or four old cankers, in marked contrast to the tens of thousands of galls observed.

In the Black Hills, on the other hand, a pine with a few dozen galls usually bears trunk cankers too. Older trees may bear cankers near the base but no branch galls at all--presumably the old galls have been lost as the lower branches fell, so that only the trunk infections remain as evidence of an outbreak dating from perhaps a century ago. On lodgepole pine, as well as ponderosa, the ratio of branch galls to trunk cankers is very much higher in the Inland Empire than in central Montana, Wyoming, Colorado or Utah.

It is easy to trace the development of trunk cankers from primary galls, and with regard to internal anatomy, galls and cankers are identical. Aecia are the same, whether on branches or trunks. Thus there should be no question of the identity of the gall-forming rust with the canker-forming one. But why is canker formation from galls not equally common in different regions? I don't know. A number of hypotheses have been suggested--for instance, faster development of thick bark by pines in the Inland Empire than elsewhere, preventing establishment of the rust in trunks. But no known theory seems to explain all the facts. It remains to be seen whether this puzzling geographic variation is explained by differences in races of the rust, by races of the hosts, or by differences in climate.

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USE OF ANTIBIOTICS IN THE CONTROL OF WHITE PINE BLISTER RUST

Virgil D. Moss

Research to discover a systemic to save western white pines infected with blister rust started in 1949. It was not until 1953, however, that trunk cankers were successfully killed with the antibiotic, Acti-dione. This was accomplished with crystalline pure material dissolved in acetone and diluted in the isoparaffinic base oil, Sovaspray 100. Solution was applied to wounds of excise trunk cankers made by cutting out dead and dying bark to facilitate spray penetration and to expose insect infestations. Trunk cankers killed with concentrations of 150, 300, and 600 ppm Acti-dione were 83, 77, and 80 per cent, respectively.

From 1953 to 1956, Acti-dione aqueous solutions and oil base emulsions fortified with various kinds and percentages of surface active agents were evaluated in trunk canker treatment. These were less than 63 per cent effective. It was quite apparent results varied with spray penetration as aqueous solutions without additives were least effective. This narrowed the potential field of carriers to petroleum fraction oils. In 1956, crystalline pure Acti-dione in acetone solvent and diluted in No. 1 fuel (stove) oil was applied to excise trunk canker wounds. This formulation was 100 per cent effective and void of serious side effects to western white pine.

New application techniques to lower treatment costs then were developed. The first of these was the slit method. If differed only in the way trunk cankers were prepared for antibiotic treatment. In place of cutting out dead and dying bark, the canker margin was slit. Slits cut 1 to 3 inches long were centered on the canker margin at the four angular summits of surface discoloration. To space slits at about 4-inch intervals around the perimeter, large trunk cankers were incised between angular summits of discoloration. Trees were examined for cankers and infected branches pruned in both excise and slit methods of treatment.

Another method was injection with a veterinary hypodermic syringe. Acti-dione oil solution was introduced downward into bark at the distal end of trunk cankers. This type of treatment was effective only on boles less than 3 inches diameter at canker center. But the method proved impractical because the syringe was easily plugged and it was difficult to contain solution in the thin-wall bark resevoir made with the needle. A single horizontal slit at the distal end of cankers was as effective. Trees still were examined for cankers and infected branches pruned.

Finally, a method evolved that was both economical and simple to execute. This was the basal stem method. It is easily applied because no technical skill is required to identify infection, incise diseased bark, and prune branches. Instead, all trees of good color and growth are treated. Spray is applied by holding the nozzle 12 to 18 inches from the bole while generously wetting the bark of trunk and branches, simultaneously. Only the lower third of the trunk is sprayed if trees are less than 12 feet tall. Trees over 12 feet tall are sprayed to a height of 5 feet or eye level. Spray is applied from opposite sides of trees to saturate all the trunk surface. The basal portion of branches are wet 12 to 18 inches from the trunk. Western white pine is sprayed with 150 ppm Acti-dione diluted in No. 1 fuel oil solution.

The basal stem method set the stage for project control activity. But the curtain couldn't go up without a quantity supply of material. This was arranged in 1957 when Drs. William Klomparens, Head, and Gerald A. Boyack, Formulation Chemist, Agricultural Research and Development, Upjohn Company, Kalamazoo, Michigan, were guests of the Forest Service in the Kaniksu National Forest. From this meeting of minds came the commercial products, Acti-dione BR "concentrate" and the Ready-To-Use mixture.

Field progress in saving diseased trees with Acti-dione has been rapid in western white pine. This is the 4-year record--from 500 trees in 1956 to treating nearly 4 million in 1959. Costs have dropped about 400 per cent since starting tree treatment with the excise method. The slit method was adopted in 1957 and used until mid-summer, 1958. Thereafter, Acti-dione has been applied by the basal stem method. In 1959, about 2 acres averaging 229 trees per acre were treated per man day.

The basal stem method accepts a lower standard of control in exchange for more economical and practical application techniques. An acceptable standard of trunk canker control is 80 per cent. This means saving 8 out of 10 diseased trees not already girdled. All lethal branch infections in tree crowns are generally killed within 2 years after tree treatment. A heavily pitched-over bark surface, that inhibits spray penetration, usually is responsible for trunk canker survival.

Efforts are being made to increase the effectiveness of the basal stem method by formulation improvements. In 1959, a statistically designed study of 138 basal stem formulations comparing Acti-dione compounds, solvents, and carrier additives was established in a pole-size western white pine stand in the Kaniksu National Forest. Test design and basic ingredients were supplied by the Upjohn Company. Compounds include Acti-dione and cycloheximide derivatives: semicarbazone, acetate, oxime, thiosemicarbazone, acetoacetate, and methylhydrazone.

Acti-dione has produced spectacular and effective results in saving diseased western white pines. To begin with, odds seemed greatly against even finding a systemic to control the obligate parasite. Then, also, it was not believed possible to accomplish control unless bark was incised to facilitate spray penetration. The millions of trees successfully treated by the basal stem method is evidence of proof to the contrary. Even more phenomenal, Acti-dione kills blister rust infection above the trunk height sprayed. Trunk and branch infections in the tops of trees as large as poles are killed by the antibiotic. Treatment and translocation of Acti-dione in mature trees is now being studied. But what was not expected, Acti-dione persists in bark at least 2 years after applying the antibiotic by the basal stem method. This investigation will be described by our guest, Dr. William Klomparens.

Still in the mill hopper are antibiotic foliar spray and immunity treatments. Foliar spray investigations began in 1949. In the interim of 11 years, 31 antifungal antibiotics were screened for candidates to control the disease on western white pine. These filtered down to two, Acti-dione and Phytoactin. Both have foliar spray potentialities for ground and aerial application. After foliar spray tests were performed with backpack equipment, Acti-dione, semicarbazone, and Phytoactin were aerially applied by helicopter in 1959. Ten acre-size plots were established in mature, pole, and sapling stands. Acti-dione and semicarbazone were applied in a 20 per cent oil emulsion, and Phytoactin in aqueous solution containing 0.1 per cent Triton X-155 additive. Concentrations were as follows: 100 ppm Acti-dione, and 100, 200, and 400 ppm semicarbazone and Phytoactin. Results of treatments will not be known until 1960.

The use of antibiotics to immunize nursery grown white pine seedlings for outplanting before or even without ribes destruction is another promising control method. Presently, ribes must be destroyed before prescribed control burn areas are planted with white pine. This delays establishing a new tree crop 3 to 5 years while waiting for seeds of ribes to germinate and grow. Also, it costs more to plant cutover areas after brush and other kinds of forest vegetation begin to grow.

In 1958, several antibiotics in aqueous solution were applied in soil drench treatment to potted western white pine. Concentration levels tested were 25, 50, 100, and 200 ppm. These seedlings were then artificially inoculated with the rust. Macroscopic examination shows no infection among treated seedlings. Multiple infection was found on all untreated check trees. The question now is the length of time the antibiotic will persist in seedlings to prevent new blister rust infection. This will be answered by repeated exposure to artificial inoculation. Acti-dione and cycloheximide acetate caused high seedling mortality. Seedling losses were about 20 per cent from oxime and semicarbazone derivatives.

Tests in 1959 included both soil drench and slurry treatments. In slurry treatment, seedlings were first dug and their roots dipped in a heavy emulsion of antibiotic and replanted. If effective, this type of treatment will be used to supplement antibiotic already in seedlings for outplanting. Antibiotics applied in soil drench and slurry treatments were cycloheximide derivatives, semicarbazone, thiosemicarbazone, oxime, acetate, methylhydrazone, and Phytoactin. Seedlings were artificially inoculated with blister rust 6 weeks after applying antibiotics.

By and large, any doubt as to whether white pines can be grown in spite of the disease has been erased with antibiotics. But antibiotics cannot do the job of blister rust control alone. Today, antibiotics can save only white pines that become infected with blister rust before ribes are destroyed. However, there is a promising future in aerial application and immunity treatments. Until these methods are fully developed, foresters must continue to employ every natural aid possible in timber management to suppress ribes and to destroy established bushes to prevent new blister rust infection.

SOME STUDIES OF ACTI-DIONE IN WESTERN WHITE PINE

Wm. Klomparens

(Abstract)

The antifungal antibiotic cycloheximide (Acti-dione) is absorbed, persists and is translocated upward in pole-sized western white pine. The antibiotic persists for at least two years in the trunks of western white pine treated by the basal stem method, a recently developed operational blister rust control technique. Cycloheximide was applied only to the lower trunk area and later recovered from needles of unsprayed branches. Cycloheximide was also translocated to needles on untreated branches of eastern white pine. Movement was via the water-conducting elements since the antibiotic could be detected in xylem tissue both at and above the site of application but was never detected in bark (phloem) tissue above the treated portion.

PROGRESS IN BREEDING BLISTER RUST RESISTANT WESTERN WHITE PINE

R. T. Bingham

The last time I spoke to this conference on the subject of breeding for resistance to blister rust was in December 1955. A lot has happened since that time, and this is a welcome opportunity to bring you up to date. First, a few slides to refresh your memory on matters covered in my 1955 report and to bring you up to date on more recent developments.

(Series of 20 Kodachrome slides)

Now that you are pictorially up to date, lets take a look at the results of first generation breeding work, and at what these results mean in respect to the production of resistant planting stock in the near future.

Please refer to Table I (mimeo handout) and note the following points:

1. Control-pollinated F_1 progenies are arrayed opposite "line" parents (first vertical column) under various "other" parents (second horizontal row) regardless of which parent was the mother tree in the cross.

2. Certain "line" parents are consistently good (i.e. 17, 19, 22, and 58) or poor (i.e. 16 and 30) in transmitting resistance to their children, as shown by performance in a number of different matings arrayed across the table.

3. Poor parents when crossed with good parents produce progenies lower than average in survival, in respect to the average good-parent progeny, and, fortunately, vice versa. A sort-of plus and minus additive scheme seems to be in effect.

4. Consistently good parents like 17, 19, 22, and 58, when crossed among themselves (as in the six progenies marked with an asterisk) are among the best tested. These parents not only transmit resistance to all their progenies (so-called general combining ability), but show that several different resistance genes are contained in these good parents and that their effects are additive.

The consistency of performance by progenies within parental lines, and the additive nature of the resistance genes involved, is extremely important to future progress via selection and breeding. From data of this sort we can estimate first how effective future selection is likely to be, and second the likely gain per generation of breeding work.

Efficacy of selection is measured by an index called heritability. This is merely the ratio of variation due to additively genetic differences vs. the total (environmental, non-additive genetic, and additive genetic variation) ($H = \frac{Vg}{Vg + Ve}$). In other words, how much is the similarity of progenies within lines due to inheritance in an additively genetic scheme, how much is the dissimilarity between progenies within lines due to differences in environment, error in measurement of resistance, and to non-additive gene effects?

If inheritance were perfect, the ratio (heritability) would be 1.00 or 100%. All variation between progenies within lines would be induced by the "other" parents in some strictly additive scheme. For example, the net effect of poor parent 16 would be to decrease survival in all its progenies by say 10%, while the net effect of good parent 17 would be to increase survival by say 15%. A glance at the data will reveal that no such clearcut additive scheme is in effect. This is almost always the case in early-generation, segregating progenies. These F_1 progenies do, however, indicate a high level of heritability of resistance factors, i.e. about 70%. In effect, this means that when we choose a given seedling for future breeding we will have chosen a truly resistant seedling containing genes with an additive effect with about 70% efficiency. Selection should be rather highly efficient in progeny tests, with considerable assurance that the correct individuals have been chosen and that the additive nature of their gene effects will yield a real, genetic gain on future breeding.

Suppose for future breeding we were to choose survivors from within the six progenies of parents displaying general combining ability for rust resistance (those marked with an asterisk in Table 1). There is a good reason for this particular choice, since these seedlings, like their parents, should be capable of crossing in any direction in a seed orchard of similar selections, all crosses giving a high level of resistance. These six progenies, removing the percentage of "escape" seedlings as exemplified by survival in OP x OP (Control) lots, average 30% in survival. Starting from this 30% platform, or so-called selection differential (s), we can estimate likely progress per generation as about 70% (H) x 30% (s) equal to 21% per generation. Obviously, this rapid gain can persist for only a few generations of breeding. Also, we need more wild parents like the four good parents 17, 19, 22, and 58, to avoid inbreeding effects in seed orchards.

In practical terms, however, the predicted level of resistance in F_2 plants (30% + 21% = 51%) means that experimental production and testing of stock likely having a useful (50%) level of resistance may be only ten years away; mass-production and large-scale planting of this stock only 20-30 years away. This experimental production and testing of F_2 plants will prove or disprove the above estimates before it is necessary to enter the seed orchard business in a big way. Meanwhile, we are preparing to do just that, beginning with securing and testing many more resistant parents and proceeding with expanded work in seed orchard technology.

(Table 1 follows on next page)

Table 1. Percentages of surviving seedlings recovered in progenies of 21 parents, arrayed by parental lines. 1/

Line Parent	Other Parent																						Number Progs. 2/	Line Mean 2/	Ranking
	1	10	15	16	17	18	19	20	21	22	23	24	25	27	28	29	30	37	38	39	58	OP			
1			8	7			18	5		35						3	9						7	12.1	
10							16						8										2	12.0	
15	8												18				14					6	3	13.3	
16	7						7	6	5		12		4				3				15	9	8	7.4	
17							37*		34	36*	23		25				24	33			49*	20	8	32.6	1
18							16						12				14				13	5	4	13.8	
19	18	16		7	37	16	34	23	40	30*					22	5	16		18	24	28*	7	14	21.4	6
20	5			6			23			40		25		5			6			4		3	8	14.2	
21				5	34		40						6				5	1			16	14	7	15.3	
22	35				36		30	40					22			6	17				34*	6	8	27.5	3
23				12	23																	13	2	17.5	8
24								25												25	38	7	3	29.3	2?
25		8	18	4	25	12			6	22							19				35	11	9	16.6	
27								5														2	1	5.0	
28							22															0	1	22.0	5?
29	3						5			6											24		4	9.5	
30	9		14	3	24	14	16	6	5	17			19					8			21	6	12	13.0	
37					33				1								8				23		4	16.2	9
38							18																1	18.0	7
39							24	4				25								15	11		4	16.0	10
58				15	49	13	28		16	34		38	35			24	21	23		11	26	14	12	25.6	4
OP			6	9	20	5	7	3	14	6	13	7	11	2	0		6				14	5.3 3/	15	8.2	

Selfs

1/ Av. of 9 replicates, together totaling 81 seedlings.
2/ Excluding all self- or open-pollinated progenies.
3/ Average survival in 5 presumably non-resistant control progenies (total 400 seedlings) was 5.3%, considered mostly "escapes".

SIGNIFICANCE OF RUSTS IN FOREST NURSERIES

J. E. Nighswander

The prevalence of certain rusts in forest nurseries represents a dual problem which must be faced by the forest manager. The initial and most obvious of course is the problem of mortality of nursery seedlings due either directly or indirectly to rust infections. Reports of consistent heavy economic loss in nurseries attributable to rust fungi are relatively rare. However in a few specific geographic locations, rusts have been solely responsible for limiting the production of some tree species. The fusiform rust caused by Cronartium fusiforme Hedgc. and Hunt might be cited as an example. Sleeth (2) reported that 50 per cent mortality of slash and loblolly pine in some southeastern nurseries was not uncommon, and that 3 million rust-infected seedlings were culled at a single nursery in one year. In the large majority of nurseries in North America, however, the incidence of stem and leaf rust infection is apparently low enough to pass unnoticed with only a few occasional sporadic outbreaks to cause some concern. It is in these "low incidence nurseries" that the significance of rusts is perhaps very much underestimated.

The forest nursery as an entity undoubtedly represents the most unnatural of the forester's manipulations of the forest, and the forest manager must remain aware of the inherent disadvantages of the practice. One of the most serious being that every nursery can be considered a potential "clearing house" for the introduction, cultivation and distribution of disease organisms. The characteristics of some rust fungi make them particularly prone to spread by such means. In addition, although the consequence of the transfer of a rust from one continent to another has in the past been more vividly demonstrated than the consequence of transfer across natural barriers within continents, we have no reason to believe that the latter could not be as serious.

Both foliage and stem rusts have been reported as common pathogens in North American nurseries. Members of the stem infecting group in general, however, represent the more serious problem to the nursery manager. Primarily the effect on the host is invariably more permanent and more lethal. In addition stem rusts tend to have a longer incubation period, which results in less assurance of detection during lifting and packing operations.

Attempts to control various rusts in forest nurseries have in the past followed two general lines of approach, 1) by the eradication of the secondary host, 2) by the application of protective fungicides. Experience has indicated that either method can be applied with maximum efficiency only when the biology of the causal rust is known (3,4,5). To illustrate this I will describe some phases of an investigation conducted at a nursery located near Wisconsin Rapids, Wisconsin where a high incidence of rust galls incited by the rust Cronartium cerebrum (Beck) Hedgc. and Long had been recorded in some years on jack pine seedlings. Eradication of the secondary host (Quercus Sp.) was not in this instance practicable. Therefore control by fungicides represented the only apparent solution to the problem.

A study of the biology of the rust revealed that a series of favorable events was necessary for the "build-up" of infection on oak and subsequent infection of pine to occur. Initial infection of oak by aeciospores was conditioned by at least 10 hours of saturated air accompanied by free water with the temperature between 8 and 28° C. Late spring frosts and dry weather during Aeciospore dissemination limited spread. Secondary spread by urediospores was limited by dry weather and the decreasing susceptibility of oak leaves with age.

Infection of pine was only possible when viable teliospores were present on oak. In central Wisconsin they were usually present from the first week in June to the first of July if secondary spread by urediospores did not occur, or for about 2 weeks longer if secondary spread did take place. A period of 13 hours of 100 per cent relative humidity following a rainfall was necessary for the production and germination of basidiospores.

A review of nursery weather data indicated that in some years conditions favorable for pine infection did not occur and that in other years they occurred one or more times during the season. This suggests that the timing of fungicide applications to coincide with periods favorable for pine infection could be achieved.

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MICROCLIMATE PHASES OF BLISTER RUST CONTROL

Merle G. Lloyd

Problem of Management

It has not been economically feasible to attempt to grow white pine on all the white pine lands in the Inland Empire and protect it from blister rust. Management is confronted with the problem of just where control should be practised and planting done for best results.

Meteorological Problem Isolated

The infection stage of the white pine rust is dependent, in part, upon favorable meteorological conditions. Other things being equal, duration of weather favorable for production and dissemination of sporidia and infection of pine will determine infection patterns. The meteorological factors involved in pine infection are moisture and favorable temperatures for production of sporidia and pine infection, air movement for transport of sporidia, and atmospheric turbulence for dispersion of sporidia. Nonmeteorological factors such as surface roughness and topography affect turbulence and direction and speed of wind.

The weather varies from day to day, from year to year, and between localities. Within the range of western white pine, there should be seasons as well as areas more or less favorable or unfavorable for the rust. It is conceded that the weather in the Inland Empire is generally favorable for the rust. In spite of this, control people have observed differences in conditions that extend through even the exceptionally favorable "wave years." They can account for these differences only by microclimate. They have asked the question, "What are the differences in microclimate between these areas, and do they account for the differences in rust behavior?" If these differences can be explained by microclimate, they ask the question, "Can the best areas for planting white pine and controlling the rust be selected based on microclimate thereon encountered?" To answer this question information is needed on width of protective zones and ribes tolerance under the variety of conditions encountered in the area. Other factors being equal, microclimate existing in each area will determine their standards.

My purpose in the applied climatological approach to the blister rust problem is to analyze the meteorological conditions associated with the rust's intensification and spread with a view of modifying the blister rust control operation to advantage. The meteorological question as isolated from the over-all problem is, "How often do meteorological conditions favorable and unfavorable for the rust occur under the variety of topographic and vegetative conditions encountered in the Inland Empire?" We have some of the information needed to answer this question.

Climatic Requirements for Rust Defined

Climatic requirements for the rust have been defined. Mr. Offord distributed an outline of requirements for the various stages of the rust, prepared by the California Station at the 1956 meeting in El Paso. Although each spore stage of the rust requires favorable temperatures and moisture conditions, some of them develop over such a broad range of temperatures, with such a short period of saturated air, that favorable conditions can be expected to occur in nature each year. We are most interested in those stages where temperature or lack of moisture may inhibit or limit the rust.

In Wisconsin, Van Arsdel et al. (9) observed that 10 days with temperatures 95° F. or higher would inhibit rust development. They also found that a conditioning period of 2 weeks of cool weather with no 3 consecutive days above 82° F. was needed for first production of fertile telia.

In New York, Hirt (5) observed that sporidia did not form during moist periods, otherwise of sufficient duration for their formation, when accompanying temperatures were high.

Bega (2) reports variation in conditions encountered in California from those reported by Van Arsdel in Wisconsin. During 3 years of field and laboratory studies, he found that temperature alone as it occurs under the dry conditions encountered in California (104° F. at 55 per cent RH) did not inhibit telia. However, he did find that high humidity and somewhat lower temperatures (88° F. at 80 per cent RH) sterilized telia. He is still testing combinations of temperature and humidity to see what extremes teliospores can tolerate. Basic studies under laboratory conditions, such as these, should be continued.

Variation of Weather over Inland Empire

We have a fund of weather information obtained at long-period weather stations in and near the white pine belt. Weather data are available for 48 localities, 22 of which have long periods of record. This information can be used to determine chances of occurrence of weather favorable and unfavorable for rust intensification and spread. The data will tell us whether the climate is uniform over the Inland Empire with variations superimposed due to topography, or whether there are two or more subdivisions in the general climate. It will give us an objective measure of just how often conditions favor rust.

Variation of Microclimate in Mountainous Terrain

We know a great deal about variation of microclimate in mountainous terrain. There is considerable information in the literature on the subject and I have made several studies of variation of temperature, humidity, and air movement within small areas of the Inland Empire. As relationships between topography and vegetative cover and the climatic elements are established, it will become possible to extend chances for rust occurrence at long-period stations to nearby white pine working units.

Problem One of Small Scale Dispersion

Sporidia of *Cronartium ribicola* are formed under conditions of high humidity and proceed to germinate immediately. Bega (1) has shown that teliospore germination and subsequent casting of sporidia are not instantaneous phenomena; rather the rate of sporidia casting continues at a given high level for a considerable time period. He found a representative telial column started casting sporidia 8½ hours after subjection to 100 per cent humidity, and complete exhaustion of the column took 70 hours.

Van Arsdel (8), on the other hand, has observed what appeared to be release of sporidia in mass. In a 3-day wet period in northern Wisconsin, sporidia were released all at once. At Madison, a 2-day wet period almost completed the cycle but was not quite long enough; spores remained attached to the basidia. The implication was that free water might be a deciding factor in the release of sporidia. More information is needed on this problem.

Sporidia of blister rust are 8 to 12 microns in diameter. Their terminal velocities are estimated to be 1 to 2 feet per minute in still air. Studies by the U. S. Weather Bureau (7) have shown that particles with fall rates of less than 2 feet per minute move with the volume of air in which they are contained. Their dispersion, therefore, reduces to wind transport and eddy diffusion.

From studies made in chemical warfare, atomic energy, and air pollution, we can determine concentrations of sporidia at given distances from a ribes bush producing sporidia at a given rate. The problem is one of small scale dispersion from a continuous point source. Current knowledge in the field has been recently surveyed by Cramer (4).

Equations developed by Sutton (6) give theoretical concentrations downwind from a source at the center of a "time-mean" plume that results from the complex lateral and vertical meanderings of the "instantaneous" plume. The "time-mean" plume may be compared to a time-exposure photograph of the plume from a continuous source taken with a pin-hole camera. Maximum concentrations at a given distance downwind are inversely proportional to the wind speed and directly proportional to the rate spores are emitted. Maximum concentrations diminish almost as the square of the distance.

Cramer (3) has substituted direct meteorological indicators (standard deviations of the azimuth and elevation angle of the wind direction) for generalized diffusion coefficients obtained from the vertical profile of mean wind speed of Sutton's equation. Satisfactory estimates of distribution of spores from a point source near the ground can be made from his tables and graphs if spore production, mean wind speed, frequency distribution of azimuth of wind, and thermal stratification are known. Plume width tends to decrease linearly with increasing distance. The downwind axis of the plume is approximately along the direction of the mean wind. We need information on wind speed and direction, on fluctuation of wind direction, and on thermal stratification under moist conditions in mountainous terrain to apply this information to the blister rust problem.

Air Movement in Mountainous Terrain

Considerable information is available on air movement in mountainous terrain. Studies have been made on wind behavior on elevated terrain. The deformation and intensification of wind by topography has been investigated. Slope and valley winds have been intensively studied as has vertical variation of wind above the surface and through various types of forest cover. Work is needed on air flow in the Inland Empire during moist periods and in areas where long-distance spread is suspected.

Such studies were started this summer and will be continued next fall during favorable moist periods. Results of this study will make possible a closer definition of width of protective zones. They may explain the suspected long-distance spread in some problem areas.

Summary

Management has asked, "What is the difference in microclimate between areas with low ribes population and heavy infection and areas with high ribes population and light infection?" Answers to this question will make it possible to designate and delineate areas where conditions for the rust may be so favorable that even a few remaining ribes could cause a rust buildup that could not be tolerated.

Management also wants to know what air flow conditions prevail in areas where long-distance spread may be involved. If basic criteria for long-distance spread can be established and recognized when observed on working units, then they can be considered in planning eradication work.

When these questions have been answered, standards for ribes tolerance and for width of protective zones can be established on each blister rust working unit. Areas for protection and performing local ribes eradication can be selected which will not require protective zones of proportions beyond which it is not economically feasible to eradicate ribes. Areas where local intensification from a few remaining ribes might be expected can be avoided.

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GUIDELINES FOR ESTIMATING THE SURVIVAL OF FIRE-DAMAGED TREES

Willis W. Wagener

Forest fires are a recurrent problem in California. Up to the latter part of September of the current year over 91,000 acres of timbered lands had been burned over this season and since that time approximately 47,000 acres have been added to the total. Salvaged logs from the larger of the resultant burns will tax the available mill facilities. Some loss from stains and decay will undoubtedly be incurred before salvage can be completed. The supply of seed, planting stock, and funds for the regeneration of the burned-over lands will be wholly inadequate to accomplish the job needed. Yield schedules for the districts in which the large fires occurred will be thrown completely out of line.

Under these conditions it is important to save as many as possible of the trees that may be expected to recover. Equally important is the saving of a cone crop now present in the first-year stage on many of the injured ponderosa pines, some of which may not remain alive through the year following seed dispersal. The seed will come at a strategic time next fall and it will all be needed.

Our observational studies on the survival of trees after fire began in 1939, following a request from the Forest Service for an opinion on survival on a burn in recently logged ponderosa pine. A good reserve of thrifty trees had been left in the logging and the Forest Service wanted to save all of these that would live through. On examination of the area we were impressed by our lack of knowledge and experience in interpreting what we saw. The subsequent series of studies, in which sample damaged trees were followed until mortality on the areas had returned to normal, have been completed on 30 burns in the pine region of California. These have been distributed not only geographically but also by date of occurrence over the season. At first they were confined to ponderosa and Jeffrey pines, the species most in question with respect to survival, but were later extended to other conifers.

<u>Basic considerations affecting survival</u>: A number of reports on tree

survival following fire have appeared in the literature but, almost without exception, they have been entirely empirical, with conclusions drawn from only a single fire. Little or no attention has been given to the physiological condition of the tree at the time of the fire, to site influences on survival, or to aspects of injury other than foliage kill. All may have a bearing on survival.

Basically, the chances for a conifer to live following fire damage depend on the extent of the damage, the food reserves and growth factor supply available from which the injury can be repaired and the site factors that will influence subsequent growth. A tree is most vulnerable to fire injury during the period when length growth is taking place. Such growth is almost entirely from reserves of the previous season. During its progress there is no protected terminal bud and the newly formed twig tissues are soft and easily injured. Fortunately, climatic conditions are such that few serious fires occur during this period.

As the season progressed the tree not only has an opportunity to rebuild reserves, even though a part is diverted to diameter growth, but it becomes better protected to withstand injury if it is a ponderosa pine or a similar species in which the twigs are relatively stout and the buds large and well-covered. In coniferous species with thin twigs and relatively small and unprotected buds the time of the fire is less important. In them, crown injury is likely to coincide closely with visible foliage injury and one can estimate quite closely what the remaining live crown will be, even shortly after a fire. In contrast, estimates under similar conditions of surviving live crown on ponderosa or Jeffrey pines may be considerably in error, especially if made by one with limited experience. An example is provided by one of our early study areas, on a burn resulting from a fast-moving October fire. On ponderosa pines with an average estimated foliage kill of 74 per cent, the estimates of live crown, i.e., the percentage of crown with live twigs and buds, were too low by 24 per cent on the average and in individual cases were as much as 40 per cent in error. All of the sample trees survived.

After the main surge of length growth is completed in ponderosa pine, the anatomical and physiological conditions influencing survival change quite rapidly. Even a few weeks time may change the prospects, fire conditions being equal. On this account the date of occurrence of the fire in relation to the stage of growth development of trees on the area is important in attempting to assess fire damage. Trees scorched by early-season fires have had little opportunity to accumulate reserves and sufficient remaining green crown is needed to synthesize enough food to carry the tree through the balance of that season and to provide for length growth the following spring. As a rough approximation, about 25 per cent of green foliage seems to be needed to pull a previously thrifty tree through after a late June or early July fire at medium elevations. Criteria with respect to dates need to be adjusted in seasons in which growth has begun very early or very late.

<u>Relation of growth rate and site to survival</u>: In general, survival prospects correspond with growth vigor prior to the fire. With

equal injury, young trees on good sites have the best chance of recovery and old, overmature trees on poor sites, the least. Overmature ponderosa pines are usually making slow growth before a fire and with even moderate fire injury they become quite susceptible to attack around the base by red turpentine beetles. These basal attacks, if numerous, are often followed later by bole attacks by the western pine beetle. On this account, old, overmature trees, especially of ponderosa or Jeffrey pines, are poor prospects to leave following fire unless damage to them is quite limited. With respect to site influence, it has been found that more allowance has to be made on burns east of the Sierra and Cascade summits than on those on the west slopes if good survival is to be anticipated, because of the generally slower growth under East Side conditions than on the West.

Crown damage and survival: Most of the mortality in the sample trees followed by us was in trees with a foliage kill of 90 per cent or more and a twig and bud kill exceeding 50 per cent. Exceptions were principally on burns where there was no salvage or salvage was delayed, permitting bark beetle populations to build up. Under such conditions even completely green trees may be attacked if they are close to others that are being invaded. Many trees with more than 90 per cent of foliage kill survived if half or more of the twigs and buds remained alive and the fire occurred after most of the seasonal growth for the year had been completed.

In judging survival potentials in ponderosa or Jeffrey pines, the proportion of twig and bud kill is much more important than the proportion of needle scorch, because if the twigs and buds are living the loss of needles is in part only temporary. It is the amount of foliage present the year following the fire that largely determines whether or not the tree will succumb, since the growth that the tree is able to make during the two years after the fire has a strong influence on the probability of beetle attack. Most trees not initially killed or mortally damaged by a fire succumb during the second season after its occurrence if they die at all.

For other conifers, such as sugar pine, white fir, Douglas-fir and incense-cedar, the distinction between foliage kill and twig and bud kill is not so important because the two closely coincide, as already noted. In these species about 40 per cent of green crown is usually needed if the tree is to survive.

Cambium injury and survival: After a fire a tree has only a certain amount of food reserves that can be drawn on to repair the damage. If, in addition to crown injury, there is also injury to the cambium, a part of these reserves is diverted to callus formation around the wound and not so much is available for recovery elsewhere. In addition, patch kills of cambium of material size attract beetles or borers, the larvae of which are likely to extend the damaged area and to introduce stain organisms which cut off conduction in the underlying sapwood.

Most errors in the marking of timber on a burn appear to arise from insufficient attention to cambial injury. In the pines, damage to the cambium is not hard to recognize if one chops through the bark near ground level on the lee side of the tree with respect to the fire movement, or on the uphill side on trees located on slopes. In ponderosa pines small areas of patch kill of cambium near the base do not seem to greatly jeopardize survival, nor are narrow strips of kill or of browning of the inner bark under the bark crevices of importance in survival unless they are numerous. On the other hand, large patch kills, extending up several feet or more, when occurring with severe crown injury, definitely reduce the recovery prospects for the tree.

In white fir we have found cambium injury much harder to recognize than in the pines because of the non-resinous wood and the absence of browning in the damaged tissues. No satisfactory criteria for judgment have been developed in the course of the studies, leaving the estimation of cambial damage to this species in an unsatisfactory state.

CULL FACTORS FOR HEART ROTS AND THEIR USE IN MARKING GUIDES

James W. Kimmey

The part of a living tree that is not merchantable because of defect is termed <u>cull</u>. The defect may be decayed wood, shake, fire scars, or poor form.

When the amount of cull is expressed as a per cent of the gross volume of a tree or stand, the percentage is termed the <u>cull factor</u>.

There are two general types of cull factors. One type is applied to individual tree volumes, the other to tree group or stand volumes. That applied to individual trees is based on the cull found in association with specific indicators such as conks, fire scars, or broken tops; it is called an <u>indicator factor</u>. The type of cull factor applied to tree groups or stand volume is based on total cull regardless of indicators and is called a <u>flat factor</u>.

Most cull is caused by heart rots; however, cull factors ordinarily include cull from all causes except that caused by tree form, such as crook or sweep.

Cull factors can be designed to apply to the entire volume of trees or to only a portion, such as to the sawlog portion between a predetermined stump height and a fixed top diameter. They can be designed to apply to board-foot volumes or to cubic volumes. Usually the factor for board-foot cull is larger than that for cubic cull for the same defect. Some defects, such as shake, may cause cull of board-foot volume but not cubic volume.

Cull factors ordinarily must be determined separately for each commercial tree species. Sometimes cull varies considerably from one site to another, so that it is also desirable to determine cull factors for each tree species for each site class. Within a species, the average amount of cull in a tree increases with its age. However, it is impossible or impractical, except in even-aged stands, to determine the age of each sample tree when cruising. Since tree size is ordinarily correlated with age and it is readily measured by cruisers, cull factors are usually determined for trees by diameter classes. Sometimes flat factors may be determined for tree classes that are based on tree age.

PURPOSE AND USE OF CULL FACTORS

Cull in living forest trees is of primary economic importance in the lumber industry, and the success or failure of a lumbering operation often depends on the accuracy with which estimates of cull have been made. This is true not only because cull reduces the volume of sound wood available, but also because it increases handling costs in logging and milling. The amount of cull present in a living tree is often difficult to estimate. Cruises will be in error if not correctly discounted for cull, even though gross volume measurements are accurate.

Cull factors are a scientific tool designed for use in estimating the extent of cull in a stand of timber. Gross volumes can be accurately measured, but the volume of merchantable material in a stand must be determined by estimating what portion of the total volume is useless because of cull.

Local timber cruisers with considerable experience in a particular area and timber type can often gain sufficient knowledge to estimate cull accurately in standing trees in that timber type and area, especially for the degree of utilization and type of cutting and manufacture with which they are familiar. Cruisers new to the job, or to an area and timber type, usually have difficulty in making accurate estimates of cull. The uninitiated can quickly and easily learn to apply cull factors to obtain a consistently accurate estimate of cull.

Cull factors are invaluable in large-scale timber inventories, such as the National Forest Survey, in which numerous survey crews, made up of relatively inexperienced forestry students, collect volume data over wide areas of great diversity in timber types. The primary objective and most important result of an inventory is the net volume of timber, and the accuracy of net volume determines the value and usefulness of the inventory. Periodic remeasurement is made of permanent survey plots to determine trends in cull development. Consistency in cull estimating is necessary in each subsequent examination if trends are to be accurately evaluated. Cull factors are of inestimable value for obtaining consistent cull estimates when each remeasurement is made by a different estimator.

The success of sustained yield management of timber stands depends upon an accurate prediction of the net volume of merchantable timber that may be harvested annually. The accuracy of the prediction depends upon the accuracy of an inventory, predicted growth, and predicted losses, much of which will be caused by cull. To determine the allowable cut it is therefore necessary to be able not only to accurately estimate cull now present, but also to estimate future losses from cull. Cull factors fulfill both needs.

Timber sales to be equitable must be based on accurate estimates of merchantable timber. Accurate cull estimates are requisite in the fulfillment of sale contracts. Purchasers base their bidding price on the net volume available and the cost of logging and milling, all of which are affected by cull in the timber.

Some defects that cause cull in lumber manufacture do not cause cull in pulp manufacture. Wood containing sound-wood defects, such as shake, or some defects caused by fungi, such as stained wood or the early stage of "white rot" decay, is usable for pulp manufacture with little or no loss of pulp yield. Even wood in advanced stages of decay caused by some of the "white rot" fungi is usable, but the decay reduces the yield of pulp. Cull factors can be designed to distinguish the types of cull, and permit accurate cull estimates for the market intended.

APPLICATION OF CULL FACTORS

Early cull studies in western United States were concerned mostly with decay from one heart rot fungus, or decay in one tree species. The studies were usually made at only one or two localities and involved a single site--seldom more than two sites. Cull percentages were invariably computed for trees of various ages; although this method was logical, the results were difficult to apply in cruising. Consequently, the cull information had little application as cull factors. The results had greater value for determining pathological rotation age of the tree species studied.

To be most useful in estimating cull in timber stands, factors must be readily applicable to what a cruiser can see and measure. Flat factors are the simplest to apply, but are likely to be the least accurate, especially on small areas. However, flat factors may be satisfactory and most efficient for tree species having small percentages of cull. For example, ponderosa pine in the West Coast States has little defect and is especially adaptable to use of flat factors. When sample trees are grouped by tree classes the cull factor varies by only 1 or 2 per cent from one class group to the next. Indicator factors should be used for tree species that are highly defective and especially variable in amount of defect. Most tree species that are highly defective bear indications of defect suitable for preparation of this type of cull factors. However, occasional tree species, such as incense-cedar, although highly defective, do not exhibit suitable indicators for accurately estimating cull. Flat factors must be used for such species. Some trees of nearly all species contain cull that is not manifest by external indicators. Even though indicator factors are employed for estimating cull in a species, supplemental flat factors are usually required for those trees that show no indications of cull.

Flat factors based on tree age may, under certain circumstances, be appropriate for some species, such as aspen. Aspen usually occurs in even-aged stands, or stands of 2 or 3 ages, and often lacks suitable cull indicators. Tree diameter in aspen stands is particularly variable in relation to age, because of wide ranges in site quality and stand density. Cull factors should be prepared for age groups and probably by site classes. Cruisers can determine stand ages by ring counts on increment borer cores from a relatively few sample trees.

Flat factors determined for a species in one locality may not give accurate determination of cull when applied in other localities. Before such factors are used in a new locality, they should be checked to test their applicability there. Indicator factors, on the other hand, are more likely to apply in new localities as well as they do in the locality where they were determined. However, it is well to check them because there may be additional or different indicators, in a new locality, that must be included to estimate total cull accurately.

Indicator factors, although requiring more field and office procedure than flat factors, are ordinarily more accurate both over small areas and over wide ranges of cull diversity. When large variations of cull in a tree species are associated with a single indicator such as conks of Fomes igniarius in aspen or fire scars in lodgepole pine, cull factors should be determined for the single indicator even though the tree species may contain much cull for which there are no indicators. Supplemental flat factors for the "hidden cull" must be determined in such cases. The combination of indicator factor plus supplemental flat factor will provide a greater accuracy over small or localized areas, as well as over broad areas having large variations of cull.

A cruiser who does not use cull factors, as such, estimates cull in individual sample trees, basing his estimates largely on experience and rules-of-thumb. However, he uses cull indicators, although he ordinarily uses considerable judgment along with the indicators. When a cruiser uses indicator cull factors he can, with experience and knowledge, improve his accuracy by supplementally employing his good judgment. Cull factors necessarily are average values, and an indicator factor is a general average of the amount of cull associated with a particular type of indicator. Some indicators, such as "broken top," vary considerably in severity and age. For instance, a top broken out high up in a tree bole that was sound at the time of the break will represent less cull than one broken out at the same time, but lower in a bole that contained decay before the break. And if the lower break occurred 20 years before the higher break the difference in amount of cull would be even greater. An experienced cruiser can pretty well judge the age and cause of such broken tops as well as their position in the bole, and can modify the average cull factor accordingly.

SOME CULL FACTORS DETERMINED FOR STANDS OF WESTERN UNITED STATES

Cull estimates of a sort probably have been used in western United States since the advent of lumbering there, and certainly since the start of timber inventorying. Through long experience in cruising, harvesting and manufacturing in a certain timber species, the timber men have a pretty good idea of the extent of cull usually found. They can estimate with fair accuracy the per cent of cull to be expected; and such estimates have sometimes been termed the "cull factor." Large scale inventories of western timber stands have utilized these "cull factors" in estimating net volumes. Their use in overmature stands of the principal commercial species, such as Douglas-fir in the Douglas-fir region and ponderosa pine in the pine regions, have been generally satisfactory. However, as the industry has turned increasingly to younger stands, other tree species, closer utilization in the woods and mill, and as the value of timber has increased, need for refinement in cull estimating has become evident. When the National Forest Survey was started in the western forests, the need for this refinement was most apparent, as all commercial tree species were to be accurately inventoried. Experience in estimating cull in many species and tree ages was limited, and in some species entirely lacking. If the goals of accuracy in determining net volumes were to be attained, this survey must have accurate cull factors.

When this survey was started in California in 1946 the Forest Service called on forest pathologists for help. Like the survey, studies to determine cull factors were started in the Coast Range of northwest California. Cull factors for most commercial conifers there (except redwood) and for hardwoods in that subregion were first determined by the Federal Division of Forest Pathology from 1946 to 1949, and were published by the Forest Service in 1950. Indicator factors were determined for Douglas-fir, and for red and white fir; flat factors were determined for the other conifers and the hardwoods. Later, indicator factors were determined and published for redwood. When the survey was extended to the Sierras, new flat factors were determined there for the pine species and incense-cedar, and were published in 1954. The indicator factors for Douglas-fir were used in the Sierras without any question of their applicability there; however some doubt was raised about the applicability of those for red and white firs. Consequently, a detailed check of their application in the Sierras was made. The results, published in 1957, showed that these factors applied equally well in the Sierras.

Besides their use by the Forest Service, use of the California cull factors has been adopted by California industrial and State foresters, who have been most enthusiastic about them. Some of these factors have also been used in other western states.

When the National Survey was started in Alaska, pathologists were again called on. In 1953 and 1954, cull studies were made in Southeast Alaska, and cull factors determined for Sitka spruce, western hemlock, and western redcedar were published in 1956. Both flat factors and indicator factors were determined in these studies.

Recent cull studies for Engelmann spruce and aspen were made in Colorado by the Rocky Mountain Forest and Range Experiment Station. They found that more than 85 per cent of the rot volume in spruce was associated with recognized external indicators. Cull factors have not yet been published. Earlier studies made in their territory of cull from red rot in ponderosa pine and cull in lodgepole pine, Engelmann spruce, and alpine fir have helped in estimating net volumes in Rocky Mountain timber.

In the Pacific Northwest, detailed studies of rot from Fomes pini in Douglas-fir and heart rot studies in western hemlock have supplied valuable information helpful in estimating cull in these two important conifers. Scars from logging in old growth and from thinning in young stands were found to be good indicators of cull in western hemlock.

USE OF CULL FACTORS IN MARKING GUIDES

Timber marking is a complex silvicultural job, and cull factors may be used as an aid in only a part of the job. That part applies to the top priority in general policy to salvage imminent losses, and never to leave a stand with poorer timber growing potential than it had before cutting. Cull factors, when used in cruising, directly aid in marking. Cruise estimates of cull volume often determine how the timber will be marked and cut. When stand treatment has been previously decided, marking and cruising are often simultaneous.

Cull factors enable the marker to judge the extent of cull in a tree or stand. Except in clearcutting operations, flat factors for stands have little use. Indicator factors, on the other hand, are useful in marking for all types of cutting. They enable the marker to select sound seed trees in seed-tree harvest cuts, and to recognize the most defective trees in shelterwood, selection, or release cuttings.

Cull factors are especially useful in intermediate cuttings for thinning, improvement cuts, sanitation cuts, and salvage cuts. In marking for such cuts, cull indicators aid the marker in attaining the objectives to obtain greater total yield and to recover and use timber that would otherwise be lost.

Conks, fire scars, broken tops, and other injuries indicate the degree of cull, growth potential, general thrift condition, and risk rating of a tree. All these factors must be considered in marking for almost any type of partial cutting. In risk rating, all tree species are considered the highest risk when conks or other evidence of rot are present, or when serious bole injury or defect is evident that will result in breakage or imminent mortality.

NEEDS FOR CULL FACTORS

In the West, cull factors are urgently needed in the Intermountain, Northern Rocky Mountain, and Rocky Mountain regions. Probably the Northern Rocky Mountain region has most urgent need, and here the need is greatest for factors for western redcedar, western hemlock, the true firs, and lodgepole pine. Within these regions the National Forest Survey has the most immediate need for such factors, although forest managers probably have more need for them.

The needs for cull factors are evident and their priority is pretty well agreed. The one big need, however, is for money to conduct the necessary cull studies to determine the factors. When we solve that one big problem, the rest will be just a matter of research time.

BARK AS A CRITERION OF RED ROT CULL

Stuart R. Andrews

The Navajo Indian Reservation covers about 24,000 square miles in northwestern New Mexico, northeastern Arizona, and southeastern Utah.

About 5 per cent of this vast area or 742,657 acres is commercial timberland of which 458,457 acres are operable at the present time. The bulk of the operable sawtimber occurs along the Arizona-New Mexico state line on or adjacent to the Defiance Plateau and the Chuska Mountain. Both these forested areas lie within the boundaries of the original reservation of 3,500,000 acres established by the Treaty of 1868.

Except for intermittent cutting to supply small portable mills commercial logging did not start on the Navajo Reservation until 1936 when a tribal sawmill was constructed on the Defiance Plateau. For the first six years, annual cuts averaged little more than 2,000,000 board feet of ponderosa pine sawtimber. Beginning with 1941, cuts have increased steadily until now they approach 20,000,000 board feet each year, the allowable cut for the Plateau Logging Unit. Because of the location and capacity of the mill, none of the sawlogs have come from the Chuska Mountain area. Within the next few years this picture will be changed.

Currently the Navajo Tribe is laying the groundwork for an expanded wood industry on the reservation. Focal point will be a $7,000,000 plant development at Red Lake, which straddles the Arizona-New Mexico state line. Plant location and size will mean that logging units in the Chuska Mountain as well as the Defiance Plateau will be the source of raw materials.

From the foregoing description of logging on the Navajo it is evident that the Reservation has a much higher proportion of virgin ponderosa pine timberland than Arizona and New Mexico commercial forests as a whole: 85 per cent as compared with an estimated 30 per cent.

Forest land administrators throughout the Southwest had to face-up to a comparable surplus of uncut stands at the close of World War II. To cover these stands as rapidly as possible and to place them under some form of management, short cutting cycles and a light improvement-selection method of cutting were adopted. The original aim of the system, removal of 30 to 40 per cent of the net volume, has been achieved for the past 13 years. According to the U. S. Forest Service Region 3 Timber Management Handbook the objective of this system is " .... to develop vigorous well-formed stands with a good representation of all size and age classes". It is stated further that "Light and frequent cuttings have the following merits: mortality losses are reduced by the removal of declining and other high risk trees; maximum quality growth is promoted by opening up crowded groups; and establishment of reproduction is favored."

It has been recognized that these lighter cuts are not the panacea for internal defect such as heart rot, that they are for mortality losses. In this respect, the old marking systems had been more effective. They had resulted in the removal of 70 per cent or more of the original stand, and a fair proportion of the few remaining old and defective trees died before the second cut. Administrative defect studies that have been made during second cuttings of such heavily cut stands revealed negligible amounts of heart rot cull, usually less than 2 per cent of the gross volume.

What is happening under the current system? Many mature and overmature trees are being reserved if they have a low bark beetle risk rating, appear healthy and free of serious disease or mechanical injuries, and, therefore, can be expected to survive until the next cutting cycle. Internal cull in such trees is bound to increase between cuts. Furthermore, these cull volumes may seriously reduce the net scale in second cuts. They will not be absorbed in mortality losses. Unfortunately, the amount of cull that can be anticipated has been little more than a subject for speculation.

Since 1951, the light improvement-selection method of cutting has been followed on the Navajo Reservation. Two marking criteria are being applied to procure an initial cut of 35 per cent of the net volume. The first is Keen's Tree Classification as modified by Thompson, under which D trees are marked regardless of age class, all IV-C trees and III-C trees larger than 24 inches d.b.h., and IV-B trees larger than 28 inches. The second criterion is a bark beetle risk classification developed by Bongberg for the Navajo, under which all high and moderately high risk trees are marked. Because the ratio of net to gross log scale showed a marked increase when the lighter cuts were adopted, it seemed obvious that more defect was being left in reserved stands than formerly.

The Bureau of Indian Affairs has been aware of these implications for some time. The Bureau's Branch of Forestry is responsible for the sound management of Navajo timberlands, but it cannot discharge this responsibility at the expense of the present tribal sawmill or the projected plant at Red Lake. Furthermore, both the Bureau and the Navajo Tribe are dedicated to increasing the economic and sociological benefits that accrue from a stable wood industry with opportunities for training and employment of hundreds of Navajos. With so much virgin sawtimber remaining on the Reservation, the current marking policy could be modified if necessary to meet such long-range objectives.

In 1953, the Bureau of Indian Affairs initiated the first of several requests for assistance in evaluating the red rot problem on the Navajo Reservation. These requests culminated in a formal cooperative agreement between the Rocky Mountain Forest and Range Experiment Station, the Bureau, and the Navajo Tribe. Under the terms of the agreement, a defect study was made on the Defiance Plateau in 1955 and 1956.

The study was limited to 7,000 acres of the area scheduled for cutting in the Defiance Logging Unit during those years. Eighty 1/4-acre circular plots in clusters of 4 were located at random and clear-cut after they had been marked according to the existing marking rules. Both "cut" and "leave" trees were bucked into sawlogs and scaled by B.I.A. scalers. "Leave" trees then were dissected so that the actual amount of rot could be determined. Age counts were made on all trees.

Red rot was present on 100 per cent of the clusters, on 76 per cent of the plots, and in 34 per cent of the 427 plot trees. Deductions for red rot amounted to 15 per cent of the gross scale for all trees or 71 per cent of the total defect. An analysis of variance indicated a coefficient of variation for plot red rot volumes of 52 per cent.

The first important finding in the study was that there was a consistent tendency to underestimate tree ages during marking. Many trees that were older than 225 years according to ring counts were classified as Keen Age Class III on the basis of upper trunk bark color and crown characteristics. It was apparent that unless corrected this tendency could lead to an erroneous impression of age distribution and might obscure fundamental relationships between red rot and age. For example, trees that were classified as Keen Age Class III made up 62 per cent of the total gross volume in the virgin stand and they contained 69 per cent of the red rot cull. When the study trees were rearranged according to their actual ages, Age Class III (151 to 225 years) accounted for only 22 per cent of the gross and 20 per cent of the red rot cull in the virgin stand.

The second important finding was that red rot appears to be more closely related to certain bark characters than to actual ages. This is an interesting point for obvious reasons. It is easier to determine bark characters of the lower trunk than to count annual rings, and bark characters might serve as a marking criterion.

Characteristics of the bark were recorded for 271 trees cut in the study during 1956. None of the merchantable black jacks had scaleable red rot and they can be ignored. When the remaining trees were placed in Keen Age Classes III and IV on the basis of their actual ages, the cull per cents were 14 and 20, respectively. When they were assigned to these 2 classes on the basis of bark color alone, the percentages were 10 and 20. This improvement may be expressed another way: 95 per cent of the red rot was accounted for in 79 per cent of the gross volume in Class IV trees when bark color was used as compared with 78 per cent of the rot in 67 per cent of the gross when actual ages were used. Probably, use of bark color resulted in the transfer of old Class III trees to Class IV.

Inasmuch as with bark color as the criterion 95 per cent of the red rot volume occurred in Class IV trees, analysis of the relation of decay to other bark characters was limited to this class. Plate size and bark texture appeared to be about equally important. For example, rot cull amounted to 27 per cent in trees with large plates and to 26 per cent in trees with shaggy bark. Red rot cull was about the same in yellow pines with shallow and moderately shallow furrows (22 as compared with 21 per cent), whereas it was much less in trees with deep furrows (14 per cent). Trees with small bark plates in combination with moderately deep or deep furrows were invariably young yellow pines and had relatively low rot volumes.

Current marking practice on the Defiance Plateau is taking 45 per cent of the gross volume and 54 per cent of the red rot volume in the virgin stand. If marking were modified so as to remove yellow pines with shallow furrows plus those with a combination of moderately deep furrows and large plates, the first cut would remove 46 per cent of the gross and 66 per cent of the red rot volume. If all remaining high insect risk trees were marked also, the cut would take 59 per cent of the gross (about 42 per cent net) and 78 per cent of the original red rot volume. The cull per cent in residual stand would then be reduced from 14 to 9 per cent.

How much red rot can be expected when stands marked according to the light improvement-selection method are ready for second cuttings? No attempt will be made to describe the procedures followed in arriving at an estimate. In general, however, gross volume, red rot volume and cull per cent curves were developed for the residual stand, and from these curves it was estimated that in the young portion of the stand (merchantable trees less than 250 years old) gross volumes would increase by 27 per cent and red rot volumes would increase by 67 per cent in 25 years, the length of the cutting cycle for the Defiance Unit. After allowances were made for gross and rot increment of older residual trees and ingrowth of poles, it was estimated that red rot cull per cent in the residual stand in the next cutting cycle would be 17 per cent or 2 per cent more than was present in the virgin stand.

In our analyses of the Defiance data we have not yet developed any estimate of future red rot losses if virgin stands were marked more heavily on the basis of bark characteristics and risk rating. However, if cull per cent in the residual stand were reduced to 9, a maximum of about 12 could be expected in the second cutting cycle. For an annual cut of 20,000,000 board feet such a reduction would represent savings of $10,000 each year.

PORIA ROOT ROT

G. W. Wallis

Poria weirii was first recognized as a disease of Douglas fir in 1929. The Northwest Forest Pest Action Committee (1955) now rates it as the most destructive endemic root rot facing managers of coniferous forests in the Douglas fir region. Childs (1949) estimates productivity of second-growth stands in Western Oregon and Washington is, on the average, reduced by about five per cent by this disease.

Poria weirii attacks most of our major coniferous species, but extensive killing has been recorded only in Douglas fir. Deciduous species appear to be resistant. The greatest losses are found in stands from 30-150 years of age. Infection characteristically occurs in small patches or foci of dead, dying or down trees. External symptoms are variable, depending upon whether the fungus is growing primarily in the sapwood or in the heartwood.

Infection

Initial infection of young stands arises, at least in part, when roots contact disease present in the stumps of the previous crop. Spread to adjacent trees is by root contact, grafting is not essential. Poria weirii appears to be a typical root inhabiting fungus as opposed to soil inhabiting (Garrett, 1956), no evidence of growth through unsterilized soil having been found to date.

Following initial infection the fungus may continue growth in either or both of two planes: primarily in the heartwood, or ectotrophically on the bark surface. In the former, trees may appear to develop "normally", often showing no external crown symptoms, but are highly subject to windthrow as a result of weakening through decay in the major roots.

Ectotrophic growth on the bark surface may extend well in advance of wood infection, instances of over 100 cm. having been recorded. This growth habit is undoubtedly responsible for a more rapid spread of root rot through a stand than would normally be expected if the fungus was restricted to the woody tissues.

Poria weirii mycelium is apparently able to invade healthy bark. A general deterioration of uninjured bark tissues takes place below the ectotrophic growth, with subsequent infection of the cambium, as indicated by a light red-brown stain. Following invasion of the cambial tissues infection spreads longitudinally and radially, eventually girdling and killing the distal root end. The rate at which roots succumb is dependent to a certain degree upon root size and upon bark thickness. Ectotrophic mycelium on small roots is usually found only a short distance in advance of dead woody tissues indicating that penetration and girdling have been rapid. Ectotrophic growth on large roots, however, is usually well in advance of wood infection.

Control

Although this disease on Douglas fir has been known for 30 years, research is in its infancy so that it is still not possible to go much beyond listing suggested management practices for control, their application and value being dependent upon future research findings. No direct control measures are known for P. weirii. Modified silvicultural practices appear to be the most promising indirect approach but genetic and biological measures must be considered.

i) Trenching.

Poria weirii apparently spreads through a stand by root contact. Presumably, therefore, if all roots are severed around an infection centre, spread may be restricted. In one area in British Columbia, trenching effectively contained the disease for 20 years. Although this technique may have some use in a lightly infected stand a number of disadvantages can be noted.

(a) Cost of establishment and maintenance of a trench is high.

(b) Infected trees, having no external crown symptoms, may not be included in the trenched area, destroying the usefulness of the barrier.

(c) Trenching merely isolates the fungus from the remaining stand while permitting it to continue within the barrier, the disease thus being carried over to future rotations.

Shea (1958) has suggested that it may be possible to detect infection in a tree ahead of actual fungal growth by measuring certain exoenzymes.

Should future research show this to be feasible, the risks involved in trenching would be considerably reduced. Should future research show that P. weirii may be spread by spores then trenching would be of little value.

ii) Isolation zones.

It is the author's opinion that a more advantageous method of control in lightly infected stands, than that of trenching, would be the removal of all trees from the infection centres plus a suitable surround. If conducted at an early age, small stumps would deteriorate rapidly, with replacement of P. weirii by secondary soil organisms. The success of this method would necessarily require that susceptible tree species be kept out of the cut areas.

Childs (1955) has shown that within one-half-chain of a killed tree, in pole-size and larger stands, about one-half of the trees are infected, while at distances greater than one-chain few trees are infected. However, to prescribe accurately the width of a surround required to retain the fungus, more detailed information must be obtained on the extent of disease foci in stands of various ages. Rate of stump deterioration and replacement of P. weirii also requires investigation with relation to this method of control.

iii) Wide planting spacing combined with early and frequent thinning.

Wide planting spacing combined with early and frequent thinnings might conceivably maintain root contacts at a minimum and limit spread of root rot. It has been shown that roots less than one cm. in diameter may carry viable P. weirii mycelium. The spacing required to eliminate root contacts, therefore, undoubtedly would not meet with prescribed silvicultural standards. Early and frequent thinnings, however, would result in detection of infection centres at a young age, and spread might be reduced by removing a suitable isolation strip. Rapid deterioration of small stumps could subsequently lead to an area free of P. weirii, except of course for that which occurred in old growth stumps.

iv) Silvicultural thinnings.

A further method which may be suggested for destroying root contacts is that of silvicultural thinning. Successful use of this method assumes that when a tree is cut the roots die and are quickly invaded by soil organisms to the exclusion of P. weirii.

A number of thinning plots are currently under observation but as yet it is too early to expect any conclusive results. Thinning in a heavily infected stand would probably be of little value since the residual stand could contain many infected trees, with no crown symptoms, which may act as focal centres for further spread.

A great deal of research is still required before an accurate analysis of any information derived from permanent thinning plots can be made. For example:

a) What is the rate of spread of the fungus through the roots of a stump as compared to that in a living tree; i.e., will the fungus quickly permeate the roots of a stump in the absence of host vigour, passing to the roots of the residual stand before secondary organisms can become established?

b) How long does the fungus remain alive in stumps of various sizes?

c) How soon will the roots of the residual stand grow into the opening left by the cut trees to contact root rot from the infected stumps?

d) What effect does changing the soil microflora, brought about by opening up the stand, have on the growth of ectotrophic mycelium?

e) Does the increased vigour of the trees, which presumably occurs following stabilization of a stand after thinning, affect fungal invasion of the host? Most vigour classes throughout the range of Douglas fir have been observed to carry infection so this increased vigour would probably be of little consequence. The initial decline in vigour immediately following thinning may, however, conceivably have an adverse effect.

f) Poria weirii might, in some respects, be considered similar to the root rot fungus Fomes annosus. Rishbeth (1950, 1951) has shown that spores of this latter disease may infect the stumps of freshly cut pine. The possibility exists, but as yet has not been investigated, that P. weirii might be spread locally and over considerable distances by spore infection of Douglas fir stumps in thinned stands.

v) Mixed stands.

From observations made by Childs and Shea it has been suggested that P. weirii is causing less damage in mixed coniferous stands. Childs (1955) suggests that natural control of this root rot probably occurs through replacement of Douglas fir with other less susceptible species or by brush. He is of the opinion that Abies spp. are probably as susceptible as Douglas fir, western hemlock is somewhat less susceptible and western red cedar is much less susceptible.

Preliminary root excavations undertaken by the Victoria Laboratory (Wallis, 1955, 1957) produced the following information: western hemlock bore a heavy growth of ectotrophic mycelium, usually well in advance of wood infection, and penetration of the bark was common; western red cedar, on the other hand, bore only a limited growth of ectotrophic mycelium and no wood infection was encountered in the main laterals; a few minor root ends, less than one cm. in diameter, however, had succumbed.

In our present early state of knowledge it appears therefore that western red cedar is the most promising replacement for Douglas fir.

Studies of allied species are at present being intensified. Dr. Shea is undertaking to plant some of the more promising species in disease openings in an effort to test their susceptibility to infection and spread. Root excavations will be continued to study alternate species already well established in disease gaps as well as those in mixed even-aged stands. A number of personnel will shortly be engaged in work to ascertain a suitable inoculation technique. Assuming success, controlled inoculation trials of all worthwhile species will be undertaken.

vi) Crop rotation.

Crop rotation on land highly susceptible to root rot is, of course, subject to finding a species which is resistant to attack by P. weirii and economically acceptable to the industry. A rotation of a resistant crop would presumably be sufficient time for the stumps of the present stand to deteriorate and for P. weirii to be replaced by other organisms, leaving the area free from disease and suitable for a further crop of Douglas fir.

vii) Breeding for resistance.

There exists the possibility that certain Douglas firs may show some resistance to infection or to spread of P. weirii. In many infection centres trees have been observed which show no external symptoms. These trees should be examined in more detail for the presence of disease. Subjecting promising specimens to artificial inoculations may result in the selection of a resistant clone.

viii) Biological control.

Poria weirii, as stated earlier, spreads rapidly by ectotrophic growth on the root surfaces. Studies of Fomes annosus have shown that ectotrophic mycelial growth is abundant in alkaline soils while being sparse to absent in acid areas. Presence of antagonistic soil organisms, which are more abundant in acid soils, has been suggested as the reason for the apparent scarcity of ectotrophic growth in these latter soils. It may be possible, therefore, that by the addition of certain amendments to the soil in P. weirii infected stands, conditions adverse to the development of ectotrophic mycelium may be created. This, of course, would not stop spread, but would decrease it to that which occurs in the woody tissues.

The aforementioned problems are but a few of those which still require attention. Dr. Childs and his co-workers in Portland have established many permanent plots to study the effect of root rot on stand development under various environmental conditions. Direct observations on the behaviour of the fungus under varying conditions of site, climate, etc., however, have as yet not been made.

The fungus occurs throughout the range of Douglas fir in British Columbia but a detailed survey to determine its overall significance has not been undertaken.

Poria weirii may be extensive in certain localities while causing little concern in others. A detailed examination of site with relation to disease is required.

Some years ago Dr. McMinn started a study of the characteristics and ecology of healthy Douglas fir roots (1954). Continuation of this work is imperative and should be expanded to include other species if we are going to have a basic understanding of host-parasite relationships.

More detailed work on the biology of the fungus is essential.

Direct control methods such as poisoning, application of antibiotics, etc., require consideration.

The research program in both the United States and Canada is expanding. Let us hope that in the next decade it will be possible to give the forest manager a direct answer on at least a few of these suggested controls.

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DETERIORATION OF KILLED STANDS AND SLASH

G. P. Thomas

Deterioration of wood can be either destructive or useful, depending largely upon the kinds and amounts of material involved and where it is located. Logging residue of non-merchantable sizes is obviously best left to deteriorate, and at the fastest possible rate. On the other hand deterioration of logging residue of merchantable dimensions constitutes a forest loss, and should be prevented where possible. Similarly, a rapid deterioration of dead trees that occur singly or in isolated small groups is to be hoped for in the interests of good forestry, whereas the deterioration of large continuous areas of timber is to be avoided where possible. When assessing losses of this nature, we should keep in mind however that dead trees, logs, and logging residue deteriorate both in value and volume, usually quite rapidly. On this account deterioration losses of some degree can rarely be prevented, even under the most favorable of circumstances. Forest managers therefore have no choice but to accept a low level of deterioration losses in the knowledge that larger and more serious losses can be prevented.

If trees, logs, and logging residue are considered salvable because of their species, size, and location, the prime consideration in effecting their salvage is time. Time is important in the sense that the sapwood of all species and the heartwood of most deteriorates rapidly, so that within a few years the material involved seldom pays the costs of salvage. Since time is so important to the salvage of dead material it is abundantly clear that a working knowledge of the rate of deterioration, and the possible differences in this rate between woods of different species, sizes, and in different locations is equally important. In other words, forest managers should be apprised of the possibilities for the salvage of dead material under a variety of conditions.

The need for preparation to meet the special demands of salvage operations is further indicated by the uncertainty as to when large-scale losses may become imminent. This stems from the fact that trees are killed by any one or combination of several agents. In the main these are: climatic abnormalities, infectious diseases, fire, and insects. It is general knowledge that the vagaries of each of these agents can and indeed do cause unheralded damage to western forests. Consequently, the amount of timber that will be killed in any year in specified locations is unpredictable, but in the long run the killing of very large volumes of timber is assured. The purpose of this paper is to summarize our state of preparedness to meet the demands for information that will enable the planning for economic salvage of killed trees, logs, and logging residue.

Certain generalizations on the subject of deterioration are permitted as the result of work done in the west and elsewhere, as follows:

1. Sound wood from dead trees is just as durable and strong in use as sound wood from living trees.

2. Deterioration is a destructive and irreversible process. Once started this process may be arrested for long periods, but the end result is usually the complete destruction of wood.

3. Deterioration losses must be considered in terms of the lowered grades of forest products, as well as the reduced volumes derived from particular areas.

4. Deterioration takes several forms, but in the long run the damage caused by fungous stains and rots is the most serious.

5. Fungi that cause blue sapwood stain are usually the first to become established, but seldom cause rots.

6. Most of the fungi that are in the heartwood of living trees are relatively inactive once trees are killed.

7. Fungi that cause most of the rot in dead trees seldom cause much rot in normal living trees.

8. The sapwood of dead trees of all species deteriorates at a uniform fast rate under most conditions.

9. The heartwood of dead trees deteriorates at a rate roughly comparable to that for sapwood with a few notable exceptions.

10. The season of year in which timber is killed can influence the onset of deterioration processes.

These general concepts have limited practical application to actual problems. Their main value would appear to lie in providing a starting point for studies on deterioration as it is affected by a variety of conditions in nature. The results of studies already made with this in mind offer tangible proof that deterioration proceeds at different rates in woods of different species, sizes, and in different localities. Similarly, trees that are killed by different agents are known to deteriorate at different, albeit characteristic, rates. What then is known in detail about deterioration for the principal western species?

There are some 22 reports on investigations into various forms of deterioration of western conifers, 6 of which were active at January 1, 1959. These investigations have involved 13 of a total of more than 27 species of conifers that are utilized in the west today. There would appear to have been no detailed studies on deterioration of the 6 major hardwoods in the west. Three of the completed investigations were closely related studies of a single problem. Hence only some 20 problems on deterioration have been investigated in a reasonably thorough-going manner in the west. In view of this rather limited appreciation of deterioration of western species there seems little value in discussing each tree species individually. Rather a discussion of deterioration in general terms as it applies to different classes of dead material would appear to be more appropriate at this time.

Windthrown Timber

Timber of all species is at some time or other subject to windthrow. Apart from catastrophic blow-downs there is a steady drain exacted from western forests because of wind damage and subsequent lost opportunities for salvage. In respect of this problem one investigator states: "Rates of decay in windthrown timber differ appreciably from one locality to another, depending upon numerous variables whose magnitudes and effects are known only in general terms. It is therefore impossible to calculate accurately the amount of decay that will be present in a given blow-down at a given time."

This is a rather pessimistic viewpoint but is one which has characterized many investigations of deterioration, including those of windthrown timber.

The problem of deterioration in windthrown timber can be assessed on the basis of some 6 investigations of this class of material. Three of these were concerned with a single catastrophe. Deterioration of Douglas fir, sitka spruce, western hemlock, silver fir, and western red cedar has been investigated in parts of western Oregon and Washington; white spruce and alpine fir at one locality in British Columbia; and ponderosa pine at one locality in Oregon. These studies indicate that apart from decay substantial losses may be expected in the form of breakage and insect damage. It would appear also that the sapwood of all species is quickly and completely blue stained, usually within one year. Saprot is evident by the second year and is usually well advanced after 4 years, at which time heartrot is usually well established. After 5 years of deterioration the percentage loss in volume because of decay alone was as follows: western hemlock 55, silver fir 45, sitka spruce 31, white spruce 30, alpine fir 17, Douglas fir 17, western red cedar 9. When volume losses that accrue from normal heartrot are added to losses of deterioration, it can be seen that apart from western red cedar and Douglas fir the possibilities for economic salvage are marginal after 5 years of deterioration. A specific fungous flora was indicated for each of the species studies, but on the whole a select few fungi caused most of the rot. Fungi that caused white rots were often overrun by those causing brown cubical rots by the fourth year of deterioration.

Fire-killed Timber

Probably the greatest accumulation of dead timber in the west has resulted from fires, but our knowledge of deterioration in this class of timber is drawn largely from 3 investigations. These involve 5 species. This situation has been allowed to persist in the west despite the knowledge that elaborate and efficient fire suppression programs do not preclude disasters resulting from fire. Witness the fire season of 1958 in British Columbia and that for 1959 in Alberta. Apart from fires of catastrophic size, substantial volumes of standing timber are killed at the perimeters of slash burns, very little of which is salvaged immediately. It would appear that eastern Canada and United States outstrip western North America in their knowledge of deterioration of fire-killed timber.

Fire-killed Douglas fir was studied in detail in 63 localities west of the summit of the Cascade Mountains in Oregon and Washington. This study demonstrated a deterioration process as follows: an initial blue staining and ambrosia beetle attack on sapwood, followed by incipient stages of rots and by wood-borer activity, typical decay first in sapwood and later in heartwood, gradual sloughing of bark and rotted sapwood, and finally a sloughing of rotted heartwood. Small twigs and the tips of branches commenced to fall after 2 years of deterioration and larger limbs and tops after 10 years. Young growth (up to 250 years) had deteriorated by 60% of its volume in 5 years, intermediate growth (250-400 years) by 28%, and old growth (more than 400 years) by 23%. The character of the wood involved was shown to affect deterioration as follows: sapwood decays uniformly fast in all trees and usually faster than heartwood, fast-grown wood deteriorates faster than slow-grown wood; and trees with the highest proportions of sapwood decayed most quickly. The study indicated a generally similar rate of deterioration for coast and Cascade forests.

The rates and agents of deterioration in fire-killed stands of ponderosa, Jeffrey, and sugar pines, Douglas fir, and white fir were studied in 16 burns in California, the ages of the burns being from 0-17 years. The 2 main agents, fungi and insects, were closely associated in the early stages of deterioration. There was little loss in grade or volume in the first year after killing, although some degrade resulted from blue sapwood stain. Much of the sapwood was blue-stained and in early stages of decay after 2 years. Practically no sapwood remained sound after 3 years and only the larger trees were economically salvable.

Insect-killed Timber

Bark beetles have killed large volumes of timber in selected areas in the west. Similarly, but possibly less frequently, defoliating insects such as the western hemlock looper, Douglas fir tussock moth, and black-headed budworm, cause widespread killing of some western conifers. Our knowledge of deterioration of insect-killed timber is drawn largely from 7 studies, 2 each of Douglas fir and ponderosa pine, and one each of Engelmann spruce, silver fir, and western hemlock.

One hundred and eighty-year-old Douglas firs that had been killed by the Douglas fir beetle in western Oregon showed a percentage loss in volume from decay of about 20% within 2 years. This loss was equivalent to the destruction of about half of the sapwood. Most of the rot in the early stages of deterioration was located near the focus of beetle attacks on individual trees, i.e., at about the midpoint of the bole. A similar association of greatest deterioration with bark beetle foci was noted for killed Douglas fir in interior British Columbia. The latter study showed also that large logs were more decayed than small logs at corresponding heights above the ground, presumably because of the higher moisture content of large logs than that for small logs. A relationship between the appearance of killed trees in British Columbia and the extent to which they had deteriorated was noted as follows: foliage retained (8% decayed), foliage shed (14% decayed), fine twigs shed (19% decayed), branches and tops decayed (29% decayed).

Ponderosa pine that had been killed by bark beetles in the Black Hills and in southern Oregon showed a generally faster rate of deterioration than that observed for Douglas fir in western Oregon and British Columbia, whereas bark beetle-killed silver fir in western Washington was about equally decayed as Douglas fir. On the other hand Engelmann spruce in the high elevation forests of southern Utah was remarkably sound 25 years after being killed by the Engelmann spruce beetle. More than 80% of the dead trees over large areas had remained standing for 25 years and most of them were free from rot, except for small amounts of saprot close to the ground. The soundness of these trees was attributed mainly to the low moisture contents of sapwood and heartwood. Western hemlock on Vancouver Island was seriously decayed very soon after being killed in the course of an outbreak of the western hemlock looper. The losses in volume from saprot alone at 2, 4 and 7 years following mortality were 19, 36 and 67% respectively. These losses, together with the usual large heartrot losses of trees of comparable ages and sizes had rendered western hemlock unsalvable within 3 years of being killed.

Logging Residue

Studies of the rate of deterioration of logging residue are useful on the one hand to demonstrate the feasibility of salvage logging within specified periods, and on the other hand to show how long it should take logging residue to deteriorate completely. Studies carried out in coastal British Columbia showed that sitka spruce residue of sizes greater than 5 in. in diameter was 18% decayed within 2 years, western hemlock 22% decayed, and silver fir 35% decayed. All three species were at least 50% decayed after 3 years of deterioration. Silver fir was completely decayed within 4 years and sitka spruce and western hemlock within 5 years.

A much slower rate of deterioration was noted for lodgepole pine logging slash in Alberta. Pieces of slash larger than 2.5 in. in diameter were less than 50% decayed 7 years following logging. This study showed also that unless residue is in contact with the ground it decays very slowly under the rather dry conditions found in Alberta. The same study indicated that residue of large dimensions deteriorates more rapidly in clearcut areas than in partially cut areas, presumably because of the interception of precipitation moisture by the overstory of partially cut stands.

Summary

The record of accomplishment for investigating deterioration of killed stands and slash in the west is not outstanding. Research in this direction has been largely a matter of expediency, and there is little evidence of a sustained drive for information on deterioration, either in the past or for the immediate future. In contrast with an apparent apathy regarding the need for information on deterioration of killed stands is an awareness on the part of forest managers of the need for information on decay in living trees. It would appear therefore that while we have shown a proper concern for losses that may occur in living trees, we have failed thus far to give due recognition to present and future losses resulting from killed stands.

The mere determination of foresters to place western forests under management does not in itself preclude the killing of trees by extremes of climate, fire, insects, and diseases. Mortality resulting from such causes is bound to continue, with consequent losses to forestry. Since tree mortality is unavoidable, and also largely unpredictable both as to location and extent, it would appear that a good knowledge of how trees deteriorate under representative conditions in nature is fundamental to proper forest management. The extent of our knowledge in this regard is clearly inadequate.

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COMMITTEE REPORT ON STATUS AND NEEDS OF RESEARCH ON DWARFMISTLETOES

J. E. Bier, F. G. Hawksworth, J. R. Parmeter, and K. R. Shea (Chairman)

Highlights 1959 Research

1. Intensification and spread

   a. The 1959 disease survey data (from randomly located plots in California) showed dwarfmistletoe on one or more coniferous species on 36 of a total of 96 plots. Red fir had 93 of 223 trees (41.7 per cent) on plots infected. For other species, 15.7 per cent of white fir were infected, 12.1 per cent of ponderosa pine, 14.9 per cent of sugar pine, 4.6 per cent of Jeffrey pine, and 39.2 per cent of lodgepole pine. (Miller and Bynum, PSW)

   b. Seeding results on ponderosa and Jeffrey pines in California indicate that growth vigor of the host part influences dwarf-mistletoe establishment. Infections became established more readily on growth segments of moderate to poor vigor than on thrifty segments. This may have application in control on high quality sites. Segments on which infections became established received less estimated direct sunlight on the average than those remaining uninfected. All infections on ponderosa pine appeared on wood not over 2 years old at time of seeding, and on not over 3-year-old wood on Jeffrey pine. (Wagener, PSW)

c. Pilot silvicultural control was started on 2 national forests in Montana. (Leaphart, INT)

d. A new study was started to determine the most efficient method of making appraisal surveys of dwarfmistletoe on timber sale areas. (Graham, INT)

e. Surveys were continued in northern Idaho. (Graham, INT)

f. Improvements were made in dwarfmistletoe survey techniques but further refinements are necessary. (Childs, PNW)

g. Silvicultural control of dwarfmistletoe was undertaken on the Deschutes National Forest. A good job was done at an acceptable cost. However, further work should lower the costs appreciably. (Childs, PNW)

h. Preliminary work was begun on a cooperative study with the Intermountain Station to determine (1) the distance of spread and degree of infection in lodgepole pine reproduction and (2) the minimum age of infection. Data and samples were taken in 17 stands from 9 to 22 years old but the results have not yet been analyzed. (Hawksworth, RM)

i. Work was begun on a study to determine the effects of dwarfmistletoe on growth and mortality in immature lodgepole pine. Comparisons are made between healthy and diseased parts of the same stand. The following results were obtained in an 84-year-old stand:

	Heavy infection	Not infected
Doms. & Codoms.		
Ave. height	14 ft.	36 ft.
Ave. d.b.h.	2.1 in.	5.2 in.
Basal area/acre		
Living	58.4 sq. ft.	192.9 sq. ft.
Pct. dead	18	3
Merch. volume/acre	0 cu. ft.	1,850 cu. ft.

(Hawksworth, RM)

j. The incidence of dwarfmistletoe by host and locality are being recorded as part of the detection function of the Forest Disease Survey in Canada. (Bier, UBC)

k. An evaluation of dwarfmistletoe on 50,000 acres of ponderosa pine lands near Klamath Falls, Oregon was completed. Data were acquired during a timber cruise of the area after an intensive soils-vegetation survey. Maps showing dwarfmistletoe incidence by timber types have been prepared in conjunction with soils and vegetation maps. Dwarfmistletoe which was present on 29 per cent of the area in a patchwork pattern infected approximately 8 per cent of the cubic volume. (Shea, Weyerhaeuser)

1. Distribution of dwarfmistletoe on ponderosa pine on the Deschutes plateau in Oregon is patchy and appears to be related to topography, site, stand history, and stand condition. Mistletoe is a feature of overmature stands or occurs as a remnant from seed stands and is severe on slopes between 5-35%. (Roth, OSC)

2. Biological and Chemical Control

a. 1958 applications of Acti-dione to branch infections of *Arceuthobium campylopodum* f. *campylopodum* on Jeffrey and ponderosa pines and white fir give variable results, from no appreciable effect on either parasite or host to killing of shoots of the parasite without damage to the host, and killing of both host branch and parasite. Acti-dione in oil applied to the bases of infected Jeffrey pines was without visible effect, apparently because of the failure of the chemical to penetrate the relatively thick bark. A new series of screening tests was begun, employing 24 prospective biocides in various solvent carriers basally applied to infected young Jeffrey pines. Results are not yet evident. (Quick and Offord, PSW)

b. Three antibiotics and one herbicide were used in control tests on the Targhee National Forest in Idaho. The materials used were: Acti-dione, Semicarbazone, Phytoactin, and 2, 4-6 Trichlorobenzoic acid (sodium salts). Results were still uncertain by mid-September. (Mielke, INT)

c. Examinations of the 1958 tests of Acti-dione and maleic hydrazide indicate that those materials are ineffective against *A. americanum*.

In 1959 the following materials were tested: Solan, Karsil, Dacryl, No. 5996 (Niagara Chemical Division) and TIN-SAN (Stecker Chemicals, Inc.). There was no effect on either the host or the parasite after 3 months. Further tests with higher concentrations are planned. (Hawksworth, RM)

d. An unidentified tussock moth was found to eat the shoots of lodgepole pine dwarfmistletoe on the Targhee National Forest. This occurred over several square miles and on some areas there was hardly a shoot of the parasite remaining. Shoots were eaten down to the bark level. The insect was specific. Pine foliage was not fed upon. (Mielke, INT)

e. During dissection of dwarfmistletoe infected ponderosa pine in a histological study, 6 specimens were found to be necrotic at the site of infection. No external symptoms were noted but a *Fusarium* has been isolated from the necrotic areas. (Eslyn, RM)

f. Investigations on the resin disease of *A. americanum* were continued. The causal fungus has not been identified although inoculations have confirmed its pathogenicity. The disease has been found from northern Wyoming to central Colorado but it is abundant and damaging only in the central parts of the Roosevelt National Forest in northern Colorado. This disease is so abundant in some areas on the Roosevelt National Forest that dwarfmistletoe is, currently at least, of little importance. (Hawksworth, RM)

g. Studies on the toxicity of minor elements to ponderosa pine and dwarfmistletoe have shown the lowest toxic nutrient level in ponderosa pine as follows: Copper - 10 ppm, boron - 100 ppm, zinc - 100 ppm, manganese - 100 ppm, and iodine - 100 ppm. Boron attained a concentration of 4,200 ppm in the crown of seedlings with only slight damage suggesting a potential chemical for control of dwarfmistletoe. Additional studies are scheduled to determine toxic levels in dwarfmistletoe. (Rediske and Shea, Weyerhaeuser)

h. An unidentified web-worm was particularly prevalent this year on dwarfmistletoe near Pringle Falls, Oregon. About 1/4 of this year's seed crop was destroyed in a one-month period. (Roth, OSC)

3. Life History, Taxonomy, and Morphology

a. Infections from seeding of A. campylopodum on ponderosa pine at three locations in California and on Jeffrey pine at one of these appeared within 3 to 6 years; 61 per cent of them appeared in the fourth year. There was some indication that the mean time elapsing varied with mean seasonal temperature. (Wagener, PSW)

b. Thirteen of 96 randomly located disease survey plots in California with dwarfmistletoe on true firs had both red and white fir present. Six of the 13 plots had heavy infection on red fir but none on white fir. Three plots had heavy infection on white fir but none on red fir. Four plots had some dwarfmistletoe on both species. Thus, 9 of the 13 plots had heavy infection on one species of fir but none on the other. This supports the opinion of Parmeter and Scharpf expressed in last year's report that there are at least two forms of dwarfmistletoe on true firs of California. (Miller and Bynum, PSW)

c. The peak flowering periods in Colorado in 1959 were April 20 to May 20 for A. americanum and May 20 to June 20 for A. vaginatum. (Hawksworth, RM)

d. Abnormal fruits of A. americanum (2-seeded fruits and seeds with 2 embryos) were found in Colorado and Wyoming. (Hawksworth and Hinds, RM)

e. The occurrence of Arceuthobium vaginatum on ponderosa pine in the Hualapai Mountains, Mohave County, Arizona was confirmed this year. An earlier report that it is present in Mount Trumbull in the northern part of the county has not been verified by pathologists. (Andrews, RM)

f. Inoculation tests with A. americanum and A. vaginatum in Colorado were expanded. (Hawksworth and Hinds, RM)

g. Studies on the ballistics and seed dispersal of A. americanum and A. vaginatum were continued. (Hawksworth, RM)

4. Host-Parasite Relations

a. Dissection of 41 dated artificial infections revealed that a minimum of 2 years was required for sinkers of A. vaginatum to reach the host cambium, this was noted in two-thirds of the infections examined. In about one-third 3 years apparently were required for such growth. Radial penetration apparently was not influenced by age-at-infection within the range of the bulk of the sample (85 per cent was in current, 1-year, or 2-year-old growth). (Eslyn, RM)

b. Anatomical studies of host and parasite tissue were continued during the past year at Davis by L. Srivastava on the cooperative aid project with the PSW Station. In host studies longitudinal and transverse sections were made from (a) site of infection, (b) from regions below infection, and (c) from the shoot apex. Host species studied were: Abies (magnifica and concolor), Pinus (contorta-murrayana, ponderosa, monticola, lambertiana, sabiniana), Tsuga martensiana. Transverse and longitudinal slides were made of the aerial stems of Arceuthobium (campylopodum f. abietinum, f. campylopodum, f. blumeri) and A. americanum.

The phloem region elements previously interpreted as sieve elements by callose reaction in celloidin material were not seen and confirmed in paraffin material. Xylem contact between host and parasite was found to be direct in all four species studied. Vessel elements of the parasite were in contact with the host tracheids both in the vertical and in ray tracheids.

Frequency of contact between host and parasite xylem increases as one progresses centripetally from the host cambium. Based on (a) percentage of vascular rays infected and (b) frequency of xylem contact, the susceptibility of the four hosts studied would be rated as follows: P. contorta var. murrayana and Abies magnifica most susceptible, then P. sabiniana and P. ponderosa least susceptible. (Esau and Srivastava, Univ. of Calif., Davis)

c. Definite tropism responses of radicles toward host stem pieces were found on water agar. Similar responses were observed in the field. Plans are to investigate tropism in detail. (Parmeter and Scharpf, Univ. of Calif., Berkeley)

d. Cankers with young shoot buds were produced on digger pine in less than 6 months in greenhouse trials. (Parmeter and Scharpf, Univ. of Calif., Berkeley)

e. Experiments with radioactive CO_2 in controlled environments have shown that dwarfmistletoe of lodgepole pine conducts photosynthesis. Photosynthates were translocated to host tissue from bagged mistletoe shoots supplied with radio-tagged CO_2. Conversely, photosynthates were translocated from bagged pine needles to dwarfmistletoe on the same limb. Previous studies have shown that translocation of radioisotopes occurred both through host xylem and phloem into the dwarfmistletoe shoots. Additional investigations are planned. (Rediske and Shea, Weyerhaeuser)

f. Although much of the seed from dwarfmistletoe is last, an effective adaptation places some seed in the best possible position for infection. Seed are intercepted primarily by the foliage. When wet, it moves by means of a lubricating portion of the viscin into the faciele axile where the seed are held in place by fibrous viscin strands. Commonly, the embryo end is directed into the axil. Seed retention appears related to angle of branching both of branches and needle fascicles. Quantity of seed adhering to a branch is in the following order: Most on wood of preceding season's growth; second most on current season's growth; and third on three-year-old wood. Very little seed is found on that part of the shoot over three years old. (Roth, OSC)

Needed Research and Studies Not Yet Reported On

1. Intensification and Spread

   a. In California, observational plot studies are needed to confirm or disprove indications that on good sites moderate dwarfmistletoe (A. campylopodum) infection in young reproduction of ponderosa pine is controllable by host release through cutting alone, without supplemental control measures. (Wagener, PSW)

   b. The influence of direct sunlight on the germination and establishment of dwarfmistletoe needs exploration experimentally. (Wagener, PSW)

   c. Growth impact of dwarfmistletoe on ponderosa pine requires further study. Methods for prorating mortality losses and growth reduction should be developed. (Andrews, RM)

   d. Silvicultural control has been initiated on an experimental basis on 60 acres of ponderosa pine land. Six treatments are being applied to each of four 15-acre blocks to test the effects of cutting on the incidence of dwarfmistletoe. (Shea, Weyerhaeuser)

   e. Studies on environmental factors which condition the development and spread of dwarfmistletoe should be extended. Certain soil, topographic, and microclimatic factors are indicated. (Shea, Weyerhaeuser)

   f. The economics of control of dwarfmistletoe by presently available means should be investigated along with ways and means of utilizing materials now considered unmerchantable. (Shea, Weyerhaeuser)

   g. Determinations are needed of the treatable tree, treatable stands, and the economics of dwarfmistletoe infections and control. (Roth, OSC, Shea, Weyerhaeuser)

2. Biological and Chemical Control

   a. Testing programs in cooperation with chemical companies are needed to screen growth regulators and to aid in the development of better formulations of promising materials. (Shea, Weyerhaeuser)

3. Life History, Taxonomy, and Morphology

a. Studies were started on shoot initiation and growth, flowering and pollination, fruiting, and death of cankers. (Parmeter and Smith, Univ. of Calif., Berkeley)

b. The causes for yearly fluctuations in dwarfmistletoe seed crops should be investigated. (Parmeter, Univ. of Calif., Berkeley)

c. Plan to investigate germination of A. campylopodum. (Roth, OSC)

4. Host-Parasite Relations

a. Observations for 1959 for the prunibility study of A. vaginatum have not yet been made. (Andrews, RM)

b. Exploratory study of dwarfmistletoe host resistance. A number of phenotypically resistant trees were found and marked for observation and testing, but no results are available. (Eslyn, RM)

c. Research is being initiated at Washington State University on the biology of dwarfmistletoe on Douglas-fir and larch. The objectives include determinations of (1) infection mechanism, (2) host specificity, and (3) the host responses to the dwarfmistletoes of these two hosts. Studies are planned to include conditions for storage and germination of seed, artificial inoculations of seedlings of different ages and of twigs and branches of different ages, susceptibility of coastal Douglas-fir, and growth hormones. (Shaw, WSU)

d. The effects of dwarfmistletoe on the water economy of western hemlock. Plant parts distal to infections may have a lower level of moisture than proximal parts. Perhaps distal portions are more susceptible to attack by facultative parasites. Several "potential" fungi have been isolated from dwarfmistletoe infections and distal areas (Bier and Baranyay, Univ. B.C.)

e. Studies clarifying the hormone and/or enzyme relations during penetration and development of the parasite should be extended. (Shea, Weyerhaeuser)

PRINCIPLES AND PRACTICE OF DWARFMISTLETOE CONTROL

L. S. Gill

At the Spokane meeting of this Conference in 1955, two very able papers were given on the subject of silvicultural control of dwarfmistletoe. Lewis F. Roth (1) concluded that lack of factual knowledge, particularly on the ecology of the parasite (including host relationships), was the greatest limiting factor in planning for silvicultural control. George S. Meagher (2), in discussing a control program for his hypothetical

Arizona forest advocated immediate action only in lightly infected stands where control could obviously be accomplished without departing from existing management practices. He makes the following comment about the moderate to heavily infected areas: "Control action in these portions of the forest has purposely been postponed because we are currently unprepared to proceed with confidence."

Both of these men advocated more research before attempting a large scale silvicultural control program. Now there is no doubt that more research on dwarfmistletoe is needed but there is perhaps a question as to whether the best possible use is being made of the information already available. For example, the widespread practice of logging some of the most heavily infected trees in the belief that a measure of control is thus being achieved is contrary to the facts. Research and experience have demonstrated that unless the large populations of the parasite that have built up locally over many decades are reduced to an innocuous level there is virtually no control. There is even a chance of making the situation worse, for (1) opening the stand often stimulates the existing dwarfmistletoe to greater seed production and (2) loss of the screening effect of the cut trees sometimes facilitates its spread. J. R. Weir (3) recognized the importance of salvaging old and suppressed infected trees but goes on to say: "Their destruction, however, does not mean that a great advance is being made in eradicating the mistletoe from the region. It simply lessens the chance of infection for a time." It might be well to make the point clear in marking guides that partial selection of infected trees is a salvage and not a sanitation measure.

Another myth that has been exposed by research is the belief that severe dwarfmistletoe damage was a manifestation of poor site. The "poor site" theory has led to a widely adopted philosophy that mistletoe-damaged areas were non productive by their very nature and that it would be a waste of effort to try to control the parasite. This is true in some cases, particularly on rocky ridges, but recent surveys in lodgepole and ponderosa pine have shown that the vast majority of the damage occurs on the average to good sites of a broad region.

From a few limited studies that have been made recently it appears that the parasite infects an understory and invades an even-storied stand at the rates shown in Figure 1. Roughly then, if one-fourth acre of a 45-year-old stand is severely damaged we can expect about half an acre to be in that condition 30 years hence. Or, if we have an infected overstory tree standing above young well stocked reproduction today we can anticipate that an area 1/2 to 3/4 of an acre surrounding that tree will have been taken out of production in the course of a century. Dwarfmistletoe will be present beyond the limits of the damaged area but the loss will probably be nil; at least recent work in ponderosa pine indicates that virtually no loss in increment occurs until at about 2/3 of the crown of a victim is invaded. At that point growth drops off rapidly. Much more research is needed on the nature and progress of dwarfmistletoe damage but the information available in a few forest types at least is good enough to warrant its consideration in developing yield estimates for management plans.

Finally, the long treasured thought that dwarfmistletoe is not a killing disease has been pretty well exploded. Extensive surveys have established the fact that mortality is 2 to 3 times greater in infected than in non-infected stands. The increase is enough to arouse concern over the loss that may occur between cutting cycles. As yet research has not gone far enough to permit accurate estimates.

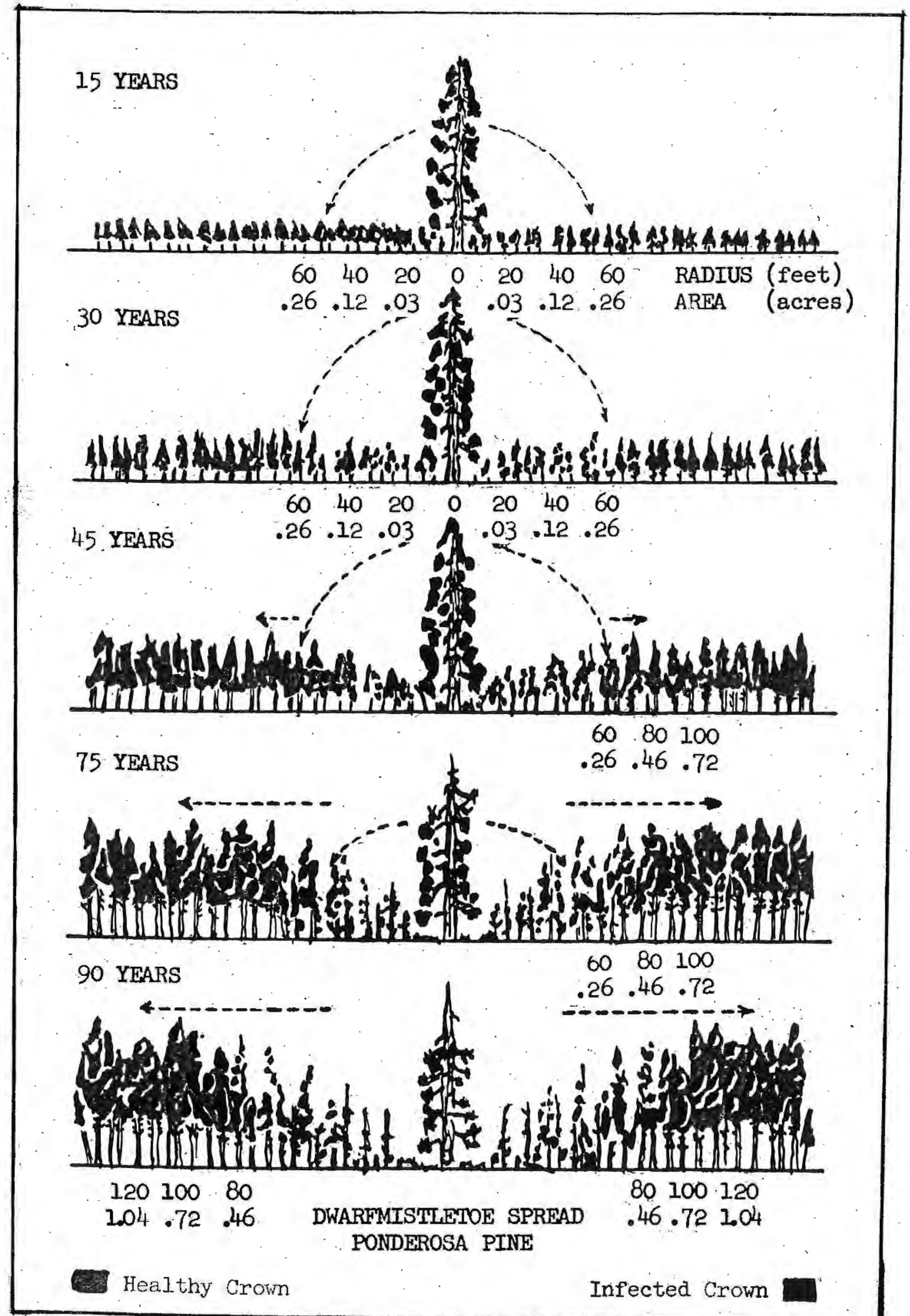
I have tried to point out that even though we do not have all the facts we would like, there is enough information pertinent to dwarfmistletoe control to warrant serious consideration of it in forest management. Why then is it not generally applied? In the case of moderately to heavily infected areas in forest types that are normally selectively cut, the answer is quite clear. First of all is our horror of bare ground; and control in some areas would leave nothing but mineral soil on limited areas. Second, is the overshadowing hope that there will soon be a market for small stems that are currently unmerchantable. There is also the conviction that a chemical will soon be produced whereby the parasite can be killed and its host then released to grow like normal individuals. Finally, interest today is largely centered in old growth forests. In the face of such obstacles it is not likely that all-out control will soon be attempted on a large scale even though research could present the soundest sort of a case for it.

On the other hand, where clearcutting is the normal practice or where infection is very light in stands that are selectively cut there is good reason to believe that silvicultural control could be justified and integrated into management practices, today. For want of a better term I have referred to this as "management control" in order to contrast a simple expedient from "silvicultural control" -- a complicated and controversial subject. Management control presupposes that all visible dwarfmistletoe is removed in the course of harvest cuts or T.S.I. operations on the treated area without departing from normal practices. It presumes wholehearted acceptance at the administrative levels and special training of the field personnel who will put it into action.

The following guidelines are offered as over-simplified suggestions to show where management control might be applied, and where it would not work. Detailed criteria would have to be spelled out for each forest region.

GUIDELINES FOR INITIATING MINIMUM MANAGEMENT CONTROL OF DWARFMISTLETOE

A.	Infected overstory present		B
A.	Overstory absent or free of dwarfmistletoe		E
B.	Merchantable overstory clear-cut	Instruction No.	1
B.	Merchantable overstory selectively cut		C
C.	Merchantable overstory even-aged		D
C.	Merchantable overstory uneven-aged	Instruction No.	2
D.	Infected volume equals or is less than prescribed cut	Instruction No.	3
D.	Infected volume greater than prescribed cut	Instruction No.	4
E.	Understory or young stand subject to T.S.I.		F
E.	Understory or young stand not subject to T.S.I.	Instruction No.	5



DWARFMISTLETOE SPREAD
PONDEROSA PINE

F.	Stand composed of seedlings and saplings only	G
F.	Stand includes pole sizes	Instruction No. 6
G.	Basal area infected equals or is less than residual allowed for T.S.I.	Instruction No. 7
G.	Basal area infected greater than residual allowed for T.S.I.	H
H.	Excess basal area reducible to limits by pruning	Instruction No. 8
H.	Excess basal area not reducible to limits by pruning	Instruction No. 4

INSTRUCTIONS

1. Apply management control - destroy all unmerchantable infected trees left in logging. (See E)

2. Ignore management control. Selection would involve age. Markers would have to decide between age and infection and would tend to leave light infections in the younger classes. Eradication would be unlikely.

3. Apply management control. Mark (or prune) all infected trees. Pruning merchantable trees is a horrifying thought to most foresters, but there seem to be situations, in ponderosa pine especially, where it might be economical and practical as a disease control measure.

4. Ignore management control as eradication of the parasite would be unlikely.

5. Ignore management control as eradication of the parasite would not be incidental to normal management practice.

6. Ignore management control. Treatment of pole stands involves spacing requirements that would not lend themselves to eradication of the parasite.

7. Apply management control - destroy all infected trees.

8. Apply management control - destroy or prune out dwarfmistletoe from all infected trees.

Conclusions

It appears that silvicultural control is a long way from general acceptance. The reasons behind this are partly due to lack of factual information but also to certain beliefs that cannot presently be shaken by any amount of dwarfmistletoe research as such. However, there is already enough information available to warrant serious considerations of a large scale management program.

In the meantime, research should continue to get all the facts that will be needed to show how, when, and where silvicultural control can be most effectively applied. For the day will come (1) when some bare ground will be tolerated if only to keep the sore from getting larger, (2) when there will either be a market for small stems or we can cut them for sanitary reasons, and (3) when more interest in second cuts will bring home the fact that infected residual stands are not yielding as much as they were supposed to. These may all come sooner than the wonder drug we all dream about, so that control may still involve calculation of the odds to see whether the costs and sacrifices today will pay off in future dividends.

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SIGNIFICANCE OF LIFE HISTORY STUDIES OF ELYTRODERMA DEFORMANS

Charles W. Waters

Elytroderma deformans (Weir) Darker, the cause of a serious and widespread disease of ponderosa pine, *Pinus ponderosa* Laws, ranks today as one of the major problems of the ponderosa pine manager. Certainly, no other disease, with the possible exception of that caused by dwarf mistletoe, exceeds it in growth loss and mortality.

Although nearly a half century has elapsed since Weir (3) called attention to its potential danger, feasible and efficient control measures still await a better understanding of its life habits.

During the period from 1916, when Weir reported the disease, to 1954, when Lightle (2) conducted an intensive study on its pathology and life history, little was added to our knowledge other than damage studies and field surveys.

Due to its seeming departure from the orthodox habits of life of the other so-called "needle casts", its life-history has been somewhat of an enigma and a prime target for assumptions and scientific guesses. Probably no other native tree pathogen has occupied such a position for so long a time.

Since control measures are nearly always dependent on an intimate knowledge of the physiological relationship which exists between a parasite and host it is evident in the case of Elytroderma that any hoped-for satisfactory control methods can only be based on a thorough knowledge of the complete life history of the pathogen. This does not rule out the need for continued damage studies, but it would render them more purposeful and capable of interpretation. For example, anyone who has observed this disease is aware that damage studies made in the late spring or early summer would probably result in higher damage estimates than when conducted in the late summer or autumn. A knowledge of the life history of the causal organism renders such an anomaly intelligible. It is almost alarming to note that of the some fifty species of needle cast fungi treated by Darker in his monograph of the Hypodermataceae (1), not a single life history is understood completely. The function of the so-called imperfect or pycnidial stage of the members of this family is unknown. It is possible that it plays no major part in the perpetuation of the fungus; still there is the probability that it does. A few field studies which were made during the current year lead me to suspect that the successful development of the pycnidia may be necessary for the subsequent production of the ascocarps.

Although Dr. Weir failed to support by illustration and experimentation some of his statements concerning the life history of Elytroderma we are forced to admit that even if on occasions he indulged in a bit of scientific guessing, he racked up a fairly high score -- much higher than we have been able to attain since. He was a keen observer.

In spite of the fact that progress has seemed slow, we are gradually building up basic information on its life history, which when completed, should be of value in the control of this as well as other diseases caused by members of the same family.

After two years of unsuccessful attempts, I feel that the presence of fungus hyphae has definitely been established in the disorganized phloem cells of the host of Elytroderma. Not only is this true of the primary phloem of the 1-year-old needles which bear the hysterothecia, but also in the youngest needles as well as the axes of the terminal buds and the developing needles contained therein. This occurs as early as a year prior to the appearance of the hyphae in the mesophyll of the needles destined to bear the fruiting bodies.

Although the infection court, time, and source of initial infection of the needles has not been irrefutably established, we do know that once established in the primary phloem, the pathogen appears to digest the walls of the sieve cells to the point where they give a blue-violet color on application of an iodine solution.

For a considerable time the IK_2I test was used to identify infected needles and stems although hyphae could not be found in the disorganized mass of tissue. Later, however, the hyphae were discovered by the following methods.

Since the walls of the phloem elements gave a positive test to iodine, it was reasoned that possibly the wall residue might be further digested with diastase, thus exposing the hyphae. Such proved to be the case. When diastase was applied, followed with a lacto-phenol-aniline blue stain, the hyphae were brought out in an unmistakable manner. Undoubted presence of the hyphae was proved when needles containing the disintegrated phloem were split, surface sterilized, and placed on a needle decoction. Germination and growth of the sclerotia-like hyphae cells which occupied the phloem area followed. Further, it was possible to dissect out diseased phloem tissue and when placed in the medium, growth of the hyphae resulted. Phloem tissue from young stems and bud axes proved amenable to the same treatment.

Thus, there remains little doubt that the disintegrated phloem areas are made up in part of the fungus hyphae. Further, that these hyphae travel distally through the phloem to the terminal buds and maintain an unbroken chain of infection into developing stems and needles.

To illustrate, I should like to describe one of the experiments conducted from the late autumn of 1957 to the mid-summer of 1958. Fifty small ponderosa pine trees averaging about one foot in height and by test, showing early stages of disintegrated phloem, were potted in the field and transported to the laboratory. Twenty were placed in the greenhouse; the remainder left outside.

Micro-sectioning of the needles of the greenhouse plants began in January but no results were obtained. The infected needles gradually dried out and not a single needle survived to the sporulation stage of the fungus. The sudden change in environment, followed by excessive transpiration, apparently hastened the death of the infected needles. The terminal buds, however, opened and developed into shoots, the needles of which, eventually displayed the characteristic phloem injury.

Sectioning of the needles of the plants outside was begun during the early part of March and continued at semi-weekly intervals. Prior to March 15, no change was noted. On March 20, the first activity occurred. This consisted of a slight enlargement of the affected phloem areas with a distinct bulging at the two lateral flanks closest to the endodermis. These are the areas of the transfusion tissue in which there is an almost continuous chain of parenchyma cells, containing starch, albumin and dense cytoplasm.

Comparative and successive tests with IK_2I solution and lacto-phenol-anilin blue in the regions of activity showed a decreasing color reaction to the former coupled with distinct hyphal stain by the latter.

Gradual movement of the hyphae continued across the transfusion tissue through the endodermis and into the mesophyll region. During the first week of April, the hyphae had concentrated between the epidermis and hypodermis and by April 15, mature pycnidiospores were developed. By May 15, the first outlines of the developing ascocarps could be detected. This time span, when compared with normal development in the field is somewhat brief. This possibly can be explained by the fact that the potted plants were in a sheltered spot and at an elevation several feet lower than the field plots from which they were removed.

Coincidental with the needle studies, sections were made of the developing terminal buds and shoots. On April 16, median longisections through a terminal bud revealed a distinct activity within the phloem area. From within the mass of phloem-hyphae conglomerate, short segments of hyphae gave rise to strands of filaments. At the regions where the dwarf shoots branched off from the stem, hypha strands could be traced into them. By the time that the needles were completely formed, a large percentage showed the hyphae fully established within the phloem area. These hyphae will subsequently provide the spore stages a year hence.

Although we are now able to understand the intensification and spread of the disease within a single tree, there still remains the solution of the question as to how, when and where, initial infection occurs. This must be brought about, either by pycnidiospores or ascospores or both. It is my belief that the pycnidiospores are essential to the development of the fungus but probably as a sexual body rather than an infecting spore.

Some field observations made during the spring of the current year strengthens my belief that the pycnidial stage is important.

During the month of May, when the pycnidial stage was at its inception, several weeks of unseasonal hot dry weather prevailed. During this time it was difficult to find sporulating pycnidia, except on the lower moister sites. Many needles bearing the diseased phloem areas, withered and died in a manner similar to those reported in the greenhouse experiments.

This resulted, during July and August, in a decidedly reduced crop of ascospores. Needles were gathered which showed the typical hysterothecia but apparently empty of viable ascospores.

It is open to discussion whether the drought actually and directly caused the death of the pathogen within the needles, or whether it acted indirectly by preventing the dissemination of viable pycnidiospores, with the result that the dicaryon or perfect phase was not initiated.

In either case, it appears that under the climatic conditions in Western Montana, the type of weather during the spring may be as controlling as that prevailing during the autumn when ascospore dissemination is thought to take place.

Somewhat at variance with the view expressed by some investigators of the disease, that its spread from tree to tree is not rapid, is my impression that the reverse can often be true.

Since 1953, when only a few brooming trees were conspicuous within a radius of 100 miles of Missoula, the disease has become established in varying degrees of intensity in almost every stand of ponderosa pine I have observed.

Clumps of reproduction, which at the time of testing showed no evidence of the disease, a year later showed 50 to 75 per cent infection. It is undoubtedly true that when viewed in a broad perspective over an extended period of years, the disease has not made alarming progress. This it seems to me is to be expected of any native disease. However, when viewed solely over shorter periods of favorable years, the spread appears to be exceedingly rapid.

There remains now only a consideration of the scant evidence I have obtained concerning initial infection.

Various lots of potted pine seedlings were exposed to the disease at weekly intervals during the time that viable ascospores were in production.

Some were sprayed with a spore suspension; others were exposed by tying infected needles to the current and year-old shoots.

After an interval of several weeks, trans-and longisections were made of needles which showed any flecks.

Hyphae were observed in both current and one-year-old needles. They could be traced from the epidermis to and into the endodermis cells. They appear similar to those of Elytroderma but in no instance could they be followed through the stomata or traced to a germinating ascospore. It is not likely that they originated in the phloem since no evidence of hyphae were seen within the stele of the needle.

These observations may or may not be significant. Only time and continued studies will provide the answer.

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POSSIBLE IMPORTANCE OF PATHOLOGICAL HEARTWOOD

Harold S. McNabb, Jr., J. W. Edgren and W. E. Eslyn

SUMMARY

A study of the decay of *Acer saccharinum* in Central Iowa (4) indicated that increment borings resulted in streaks of pathological heartwood above and below the bore holes (5, 10). Field observations showed that other wounding agents, such as insects, caused the same reaction in this species. This phenomenon was further studied in *A. saccharinum*, *A. saccharum*, *Quercus alba*, *Q. velutina*, *Prunus serotina*, and *Ulmus americana* (3, 10). The amount of pathological heartwood produced varied with the tree species, oaks producing the least. Hole treatments indicated possible extension of formation with 95 per cent ethanol and plugging of hole. Brace and bit-made holes produced less defect when contrasted with increment bored holes. The season at which the holes were bored influenced the amount of pathological heartwood in *A. saccharum*.

The formation of a discoloration-type defect adjacent to increment bore holes has been previously observed (1, 2, 6, 8, 9, 11). The relationship of this pathological heartwood to true or normal heartwood has been hinted. One study discussed the possible induction of heartwood by wounding means (8).

Gross observations in Iowa on the developmental processes of pathological and normal heartwood appeared similar. Decay zone lines and sap stain fungi followed patterns indicating that wood-inhabiting organisms reacted similarly to these types of heartwood. Wood-moisture relationships of pathological heartwood, using relative turgidity, tended to parallel those in normal heartwood formation. Upon aging, pathological heartwood appears to become identical to normal heartwood.

If pathological heartwood arises by an acceleration of normal heartwood formation, studies on the basic reactions in normal heartwood formation will be facilitated. Induction of normal heartwood in young trees not yet forming heartwood is also a possibility. The forest manager should have cognizance of this type of defect from bore-hole-like wounds. This is especially true in hardwood veneer species. Although little defect of this kind is apparent in coniferous woods, studies with color stain tests might reveal similar pathological heartwood formation (7).

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APPENDIX I

ACTIVE PROJECTS - NEW

(Project leaders' affiliations and addresses are given in Membership List, Appendix VI.)

D. Root and Soil Diseases or Relationships

59-D-1. Nursery and Replant Diseases (Robert V. Bega).

Objective: To determine major root diseases in nursery and replant stock. To devise methods of insuring disease-free planting stock.

59-D-2. Root Diseases--General (Robert V. Bega).

Objective: To determine the pathogenicity of mycorrhizal fungi on trees under stress.

59-D-3. "X" disease (J. R. Parmeter and R. V. Bega).

Objective: To determine the edaphic factors associated with the decline of ponderosa pine in southern California.

E. Foliage Diseases

59-E-1. Ponderosa pine needle cast survey (W. E. Eslyn).

Objective: To determine the distribution of needle cast of ponderosa pine in Arizona and New Mexico, and to appraise the damage caused by needle cast in terms of mortality and reduced growth.

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

59-F-1. Development of survey techniques needed prior to dwarfmistletoe control (D. P. Graham).

Objective: To develop survey techniques that may be used by forest managers to appraise the dwarfmistletoe control problem in proposed cutting areas in infected stands.

59-F-2. Penetration and development of the endophytic system of *Arceuthobium vaginatum* (Willd.) Presl. in relationship to age of host tissue (W. E. Eslyn).

Objective: To determine the influence of branch age at the time of infection upon the rate of advance of the endophytic system and to follow the developmental morphology of this system from the period of host penetration to bud formation.

59-F-3. Selection, test, and propagation of ponderosa pine resistant to the dwarfmistletoe Arceuthobium vaginatum (Willd.) Presl. (W. E. Eslyn).

Objective: To select, test, and propagate dwarfmistletoe-resistant strains of ponderosa pine and to determine the nature of resistance, e.g., whether morphological or cytological and whether genetically transmissible.

G. Stem Diseases - Stains and decays.

59-G-1. The influence of site on variations in red heartwood stain of lodgepole pine (J. E. Nighswander).

Objectives: To investigate the distribution and incidence of fungi associated with red heartwood stain of lodgepole pine; to investigate the biology of red-stain fungi *in vitro* under controlled conditions in the laboratory; to investigate various factors of site as they may influence the establishment and advance of red heartwood stains.

59-G-2. Studies on blue stain of bark-beetle-infested lodgepole pine (R. C. Robinson).

Objectives: To determine the role of blue-staining organisms in the mortality of lodgepole pine, and the inter-relationships of these organisms and associated bark beetles; to identify fungi that cause blue sapwood stain in beetle-infested trees; to establish the natural modes of introduction of blue-staining fungi into trees; to elucidate the habits of blue-staining fungi in infested trees; and to relate the habit of blue-staining fungi to the physiology of lodgepole pine.

59-G-3. The role of decay in scar-damaged Douglas fir in the Interior dry belt region of British Columbia (R. E. Foster and H. M. Craig).

Objectives: To determine the incidence and importance of decay in scarred residual Douglas fir following selective cutting.

59-G-4. Red rot in young ponderosa pine (S. R. Andrews).

Objectives: To provide information needed to determine the rate of development and ultimate importance of red rot in second-growth stands as they are related to the incidence of branch decay when the stands are young, and to changes brought about by mortality losses and natural or artificial pruning.

59-G-5. Heart rots of upper-slope species (Paul E. Aho).

Objective: To determine the extent of heart rot losses in the various tree species of upper-slope forest types, with special reference to external indicators.

59-G-6. Pathology of advanced reproduction on upper-slope clear cuts (Paul E. Aho).

Objective: To determine the extent to which heart rots and other diseases may make it inadvisable to depend on advance reproduction for stocking on upper-slope clear cuts.

H. Stem Diseases - Rusts and cankers.

59-H-1. *Cronartium comandrae* rust on lodgepole pine in Wyoming (E. A. Andrews).

Objective: To test the efficacy of systemic fungicides in the control of blister rust on lodgepole pine.

I. Wilt and Blight Diseases

59-I-1. Fungi associated with abnormal juniper mortality (W. E. Eslyn).

Objective: To survey the fungal flora associated with juniper mortality in Arizona and New Mexico and determine the possible role of these fungi in the cause of this mortality.

K. Miscellaneous Studies

59-K-1. Tests of systemic fungicides (C. D. Leaphart).

Objective: To determine if Acti-dione, semicarbazone, and phytoactin have any harmful effects on species other than western white pine and to determine if these antibiotics will control other diseases when sprayed aerially on white pine stands infected with blister rust.

59-K-2. Control of forest disease by systemic fungicides (G. M. Harvey).

Objective: To determine fungus spectra, application methods, and side effects of systemic fungicides potentially useful in forest disease control.

APPENDIX II

TERMINATED PROJECTS

54-F-3. Dwarfmistletoe survey, Arizona and New Mexico.

57-F-8. Survey of dwarfmistletoe on commercial conifers in Arizona and New Mexico.

53-G-1. Red rot in ponderosa pine (replaced by several specific projects).

57-J-3. Relative decay resistance of western hemlock and Douglas fir plywood and the effect of weathering.

In laboratory tests the decay resistance of unweathered Douglas fir and western hemlock plywood bonded with phenol formaldehyde glue was much higher than that of similar solid wood specimens. Plywood made from either sapwood or heartwood of western hemlock was similar in this respect to that of Douglas fir. Five-ply material was superior to 3-ply plywood of the same wood species. After severe weathering, decay resistance of plywood was reduced to that of the wood from which it was manufactured.

APPENDIX III

NEW OR MODIFIED TECHNIQUES

The use of a modified dowel-cutting tool to extract decay samples from standing trees (J. E. Nighswander).

A comparatively rapid method employing a modified dowel-cutting tool has been used successfully for the extraction of samples of decayed wood for isolation purposes from standing lodgepole pine trees.

The instrument is identical in principle to the "plug-cutting" tool supplied by the Rockwell Manufacturing Company, Pittsburgh, Pennsylvania, but with an extended barrel which enables the procurement of cylindrical samples 3/4 in. in diameter and up to 8 in. in length. The shank of the tool was squared to fit a wood-type hand operated brace.

The instrument, used in conjunction with tree climbing spurs, was employed to obtain heartwood samples at various heights from the trunks of trees. Each sample was placed in a stoppered test-tube to prevent desiccation enroute to the laboratory.

In addition to its rapidity, the method has a number of advantages over more conventional decay sampling procedures. The instrument is readily transported and can be easily sterilized between samples if desired. The sample obtained is of a convenient size for transport, storage and for surface sterilization during isolation procedures. Injury to the sampled tree is reduced to a minimum which permits re-sampling at a future date if desired. Use of the instrument to obtain samples for moisture determination is also under investigation.

APPENDIX IV

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APPENDIX V

MINUTES OF THE BUSINESS MEETING

Chairman Offord called the meeting to order at 1:10 p.m., December 4.

MOVED by Shea, SECONDED by Wright that the Minutes of the 1958 business meeting printed in the 1958 Proceedings be adopted. Carried.

The Treasurer submitted the following report:

		Receipts	Expenses
Registrations, 55 @ $2.00		$ 110.00	
Banquet, 50 @ $4.00		200.00	$ 228.25
Field trip			6.25
Balance from 1958		6.34	
	Totals	$ 316.34	$ 234.50
Balance in treasury as of December 4, 1959		81.84	

MOVED by Slipp, SECONDED by Wright that the Treasurer's report be accepted. Carried.

D. C. Buckland Memorial Committee. The Secretary submitted a report by Committee Chairman Bier to the effect that it would be in order to re-appraise existing plans to bind the publications of the late Dr. D. C. Buckland. As an alternative Bier suggested that a suitably inscribed speaker's rostrum and gavel be purchased for use at Western Forest Disease Work Conferences. Approval for Bier to proceed with this latter plan MOVED by Kimmey, SECONDED by Buchanan. Carried.

Dwarfmistletoe Research Committee. A full report of the "Committee on the Status and Needs of Research on Dwarfmistletoe" was presented by Committee Chairman Shea. MOVED by Foster, SECONDED by Gill that this report be accepted and printed in the Proceedings of the Seventh Conference. Carried.

MOVED by Shea, SECONDED by Childs that future reports of this Committee be distributed to members in attendance on the opening day of the Conference, that an opportunity be provided to discuss the report during the regular or business sessions, and that subject to the pleasure of the members in attendance the report be printed in the Proceedings. Carried.

Other Business

Following discussion, the Secretary was instructed to place the following opinions on record as a guide to future Conferences:

1. That papers presented at subsequent Conferences be submitted in abstract form for publication in the Proceedings when alternative publication in full was contemplated in the near future.

2. That project lists be brought up to date and presented in full in the Proceedings at intervals of approximately five years.

3. That there was an area of interest in the general field of deterioration not yet fully explored and that future Program Chairmen should consider the possibility of including this subject in future program agenda.

4. That the use of tape and other transcribing equipment to record presentations or discussions during the course of the Western Forest Disease Work Conferences would deviate from the concept of informality and free expression of opinion inherent in our objectives and that the use of such equipment should be condoned only under special circumstances and following unanimous approval of members attending.

5. MOVED by Leaphart, SECONDED by Parmeter that Conference Chairmen appoint an Interim Program Chairman on the opening day of subsequent Conferences and that the Interim Program Chairman have the following responsibilities: (1) to solicit the opinion of the members attending relative to themes, objectives, and if desired specific presentations for the following Work Conference, (2) to summarize these opinions and offer same for discussion and review during the business session; it being understood that the then newly appointed Conference Chairman should consider these opinions and suggestions in terms of possible guide lines for the subsequent meeting but that he in no way should be obligated to follow the course of action outlined. Carried.

Election of Officers

MOVED by Childs, SECONDED by Kimmey that Dr. A. K. Parker be nominated to the office of Chairman of the 1960 Work Conference. There being no further nominations, Dr. Parker was so appointed by acclamation.

MOVED by Shea, SECONDED by McNABB that Dr. F. Hawksworth be nominated to the office of Secretary-Treasurer for the 1960 Work Conference. There being no further nominations, Dr. Hawksworth was so appointed by acclamation.

Eighth Conference

Dr. Shea extended an invitation to members to hold the Eighth Western Forest Disease Work Conference in Centralia, Wash. in 1960. A further invitation to hold the Eighth Conference in Ames, Iowa was extended by Dr. McNabb. In the discussion that followed it was the opinion of the meeting:

(1) that Ames, Iowa should be regarded as a "fringe-area" if not in fact beyond the area of immediate responsibility of the Western Conference.

(2) that Section IV of the Conference Organization Policy (Pg. 122, Proceedings Fifth Conference, 1957) should be adhered to.

MOVED by Gill, SECONDED by Wright that the Eighth Western Forest Disease Work Conference be held in Centralia, Wash. in 1960. Carried.

A vote of appreciation was extended to Dr. C. G. Shaw and his associates at Washington State University for the many courtesies extended during the course of the Seventh Work Conference.

There being no further business, the Seventh Western International Forest Disease Work Conference adjourned at 2:50 p.m. on December 5.

IN MEMORIUM

NORMAN THAIN ENGELHARDT

1920 - 1958

Mr. Norman Thain Engelhardt passed away quietly in Victoria on November 1, 1958. He was born in Victoria on March 10, 1920 and completed his early schooling at this centre. He served with the Canadian Army overseas from 1942 to 1945 and on return to Canada completed his formal education, graduating from the University of British Columbia (B.S.F, 1951) and Oregon State College (M.S., 1956). By June 1958 he had completed Doctoral training from Duke University. He was seasonally employed by the Forest Pathology Laboratory in British Columbia during 1949 and 1950, joined the permanent staff of the Laboratory in May 1951, and was actively engaged in research on problems of forest decay up to his untimely death. He will be truly missed by his many friends and colleagues.

(R.E.F.)

JOHN HUNT

1921 - 1959

Dr. John Hunt was murdered by robbers in southern Idaho on August 24, 1959, while driving east to join the faculty of the Yale School of Forestry.

He served as a U. S. Navy flyer during World War II, and was a graduate of the University of Washington (B.S.F., 1949; M.S., 1951) and of the New York State College of Forestry (Ph.D., 1954). From 1954 until his resignation in 1959 he was with the Pacific Northwest Forest and Range Experiment Station. He was a good forester and a good friend.

(T.W.C.)