PROCEEDINGS OF THE 4th ANNUAL WESTERN INTERNATIONAL FOREST DISEASE WORK CONFERENCE

El Paso, Texas
November 1956

Proceedings of the 4th Annual Western International Forest Disease Work Conference

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FOREWORD

The subject matter in these Proceedings was presented at the 4th meeting of the International Western Forest Disease Work Conference held at El Paso, Texas, November 27-30, 1956.

Director Raymond Price opened the meeting with an address of welcome on behalf of the Rocky Mountain Forest and Range Experiment Station. The following delegates from Mexico brought greetings from their respective organizations:

Ing. Javier D. Garcia Lazo, Associacion Mexicana de Profesionistas Forestales.

Ing. Tito Huereca, Agent Generale de Agricultura, Chihuahua, representing the Secretaria de Agricultura y Ganderia.

Ing. Julio Riquelme Inda, Presidente Sociedad Forestal Mexicana.

The entire day of November 29 was devoted to a field trip to the Mescalero Apache Indian Reservation and the adjoining Lincoln National Forest, New Mexico. This provided an opportunity to see first hand the damage caused by dwarfmistletoe in ponderosa pine and the effects of control by removal of infected trees, and to observe the results of research on the parasite.

The highlight of the banquet on November 29 was a showing of the colored motion picture "Wilderness" and a running account of Alaskan plant and animal life by its author, Professor Dow V. Baxter of the University of Michigan.

<u>Executive Committee</u>

Lake S. Gill, Chairman
Ross W. Davidson, Secretary-Treas.

<u>Program Committee</u>

Stuart R. Andrews
Paul C. Lightle
A. E. Molnar
Vidar J. Nordin, (Chairman)

REPORT OF THE CHAIRMAN

Today we gather for the fourth consecutive year to discuss western forest disease research problems. By the time Friday noon comes around, we shall all be wiser about what is going on, who is doing it, why it is being done, and how to do it.

The meeting this year is unique in several respects. First of all, we have with us a proportionately large number who are not directly engaged in forest disease research, but who are interested in it. On behalf of the Conference, I want to extend a hearty welcome to our guests and to urge them to take an active part in the discussions.

Next, we are favored for the first time with delegates from Mexico. It is indeed a pleasure to have you gentlemen with us and we hope this is the beginning of continued participation in the Conference from your country.

Finally, the meeting place is perhaps as far from the center of our territorial sphere as it is possible to be. Because of travel limitations to such a remote spot, many of our most active members are absent today. The delegation from the Canadian laboratories is distressingly small but we are very pleased that some of you were able to make it.

It is gratifying that so many who could not attend the meeting here have submitted written contributions. We are also pleased to have four members who are attending their first meeting.

In preparing the program, the committee has held to a basic principle of the Conference, namely, that the subject matter must be of professional interest to forest pathologists. The theme they have chosen - with the blessing of the membership at large - is "Forest Disease Ecology". Such a topic is almost bound to lead to some abstractions in the technical sessions. Some of you administrative people may be inclined to look upon these as being "long-hair" - to use the cliche currently in vogue. As a matter of fact, it would be difficult to find a theme more suited to bring out the problems that forest pathologists are faced with in their efforts to serve applied forestry; for a thorough knowledge of the ecology pertinent to a disease is paramount to any successful disease control action program. Again, I urge you who are not strictly disease researchers, to enter into the discussions. In this way both parties should arrive at a better understanding of each other's objectives and needs.

It seems to me that if foresters have one general and persistent criticism of pathologists, it is our own general and persistent tendency to qualify almost every statement we make about the application of research results. By the time this meeting is over, I hope that our guests will have a better understanding of:

1. Of the gaping voids that exist in the knowledge of forest diseases,

2. Of the need for more intensive research if the losses from diseases are to be markedly reduced,

3. And the reasons why pathologists seldom have all the answers needed to solve the forester's problems.

For the benefit of you who are meeting with us for the first time, I would like to sketch the historical highlights of the International Western Forest Disease Work Conference. The idea was inspired in part at least by a similar and older work conference of forest entomologists from western Canada and the United States. At their suggestion, we formed our separate organization and held our first meeting in 1953 at Victoria, B.C. In 1954, we accepted an invitation from the entomologists to meet concurrently with them at Berkeley, California. One joint session of the two organizations was held at the meeting. The next year (1955) both groups met at the same time in Spokane, Washington, but due to an unfortunate series of circumstances, no joint sessions were held. Last year we selected El Paso for our 1956 meeting, the entomologists chose Calgary, Alberta.

The Forest Disease Work Conference was founded on informality, uninhibited discussion, and mass participation. These principles, I feel sure, explain the enthusiastic support it has received from forest pathologists representing all degrees of experience.

This year, we have continued the precedent set in 1955 of requiring panel members to prepare written scripts for their remarks. This slight lean toward formality seems to be fully justified. For one thing, it insures a well thought-out nucleus for discussion; for another, it facilitates preparation of the proceedings. The proceedings of the Spokane meeting were distributed a few weeks ago and in my opinion are an outstanding contribution from this group.

Your program committee has interjected a field trip in the middle of the meeting. I understand this is partly a matter of muscular therapy and partly a trick to see that all non-residents get a glimpse of the natural wonders of this Land of Enchantment.

In closing, I want to assure you that it has been a pleasure to work as your chairman this past year. I sincerely appreciate the fine response of the membership at large and I particularly want to thank the committees for the hard work they have done to make the fourth conference a success. I also wish to thank the folks in Forest Service Administration, the National Park Service, and the Bureau of Indian Affairs for the material assistance they will provide for Wednesday's field trip.

Lake S. Gill
Conference Chairman

LA PATOLOGIA FORESTAL EN MEXICO.

Por el Ing. Julio Riquelme Inda
Presidente de la
Sociedad Forestal Mexicana.

El estudio de la Patología Forestal en México data de muchos años atrás, pues desde que se fundó la Sociedad Mexicana de Historia Natural, el año 1869, varios naturalistas mexicanos se ocuparon de investigar algunas plagas y enfermedades de los árboles de los bosques, pero no fue sino hasta el periodo de 1900 a 1907, que la llamada entonces Comisión de Parasitología Agrícola, de la Secretaría de Fomento, Colonización e Industria, hoy denominada de Agricultura y Ganadería, comenzó seria y metódicamente a ocuparse de reunir datos e informaciones dispersos que sobre la materia se habían publicado o que permanecían inéditos y a estudiar en varias zonas boscosas del país los principales enemigos de los árboles, especialmente Artrópodos y algunos microorganismos fungosos y bacterianos.

La Comisión de Parasitología exhibía en su Museo las plagas de insectos y enfermedades de los bosques nacionales, en preparaciones adecuadas y el que habla comenzó a formular entonces unos apuntes sobre la biología de cada una de las especies clasificadas de los insectos más nocivos, publicando más tarde, en las pginas de la revista "México Forestal", órgano oficial de la Sociedad Forestal Mexicana, fundada por el ilustre conservacionista defensor de los bosques, señor Ing. Miguel A. de Quevedo, que fue conocido en México con el nombre de Apostol del Arbol, Agrupación que ahora tengo el honor de presidir, un trabajo titulado "Los Insectos Nocivos a los Bosques. Apuntes de Entomología Forestal".

Años después, en 1918, por la primera vez en México se instituyó en la Escuela Nacional Forestal, que fundó el mismo Ing. de Quevedo en la Villa de Coyoacán, cercana a la capital de la República, la cátedra de Parasitología Forestal que me fue ofrecida y de la que me hice cargo, dictando al efecto un curso especial sobre esta materia.

De entonces a la fecha se han ido creando diversos organis mos que han ampliado esos conocimientos, de tal modo que en la actualidad en varios planteles docentes oficiales y en algunas instituciones de carácter privado se imparten cursos especiales de Parasitología Agrícola y Forestal. Así se han capacitado numerosos profesionistas que ya se ocupan con mucho éxito de este género de trabajos y los estudios que se han publicado sobre la materia forman actualmente un acervo positivamente importante.

Por mi parte, en lo particular y como Presidente de la Sociedad Forestal Mexicana, he procurado continuar mis estudios al respecto al mismo tiempo que sigo tratando, empleando para ello los medios didácticos de que puedo disponer (prensa, tribuna, conferencias, etc.) de llevar al convencimiento de quienes me escuchan o leen, la necesidad de proteger los bosques contra sus enemigos inculcándoles a la vez la necesidad de que se hagan aliados de la causa forestal para la conservación de las masas arboladas. Esta acción se extiende a los centros escolares y a las autoridades de todo el país para que igualmente sean colaboradores eficaces de esta noble causa de respeto y amor al árbol.

Mediante esa campaña, que se inició ya intensamente al fundarse la Sociedad Forestal Mexicana, el año de 1921, se ha logrado formar en la conciencia del pueblo mexicano el concepto de la conservación de los árboles y de los bosques, no considerándolos intocables sino como un recurso natural que debe aprovecharse en forma racional y metódica, es decir, de acuerdo con las reglas que aconseja la Dasonomía. Muchos adeptos a esta causa se han conquistado y ahora, año por año, en la ciudad de México, capital de la República, en todas las ciudades capitales de los Estados y aun en las más pequeñas poblaciones se organizan ceremonias llamadas "Fiestas del Arbol", en las que toman parte las autoridades, los niños y niñas de las escuelas y todas las clases sociales, dedicándose todos a plantar árboles en los parques y jardines públicos y privados, en las calzadas, en las calles y naturalmente en las zonas boscosas que por cualquier circunstancia han sufrido cortes inconvenientes y destructores.

Esta campaña cultural está dando sus frutos y México espera que en unos cuantos años más la recuperación y mejor cuidado de sus bosques se lleven a cabo de un modo estrictamente cientí *fico para que sean esas grandes masas arboladas centros inagotables de producción de buenas maderas y otros diferentes productos; es decir, que conforme a estas bases de mejor y racional aprovechamiento, la conservación de los bosques sea realmente efectiva y de total beneficio para la comunidad.*

Una de las luchas más tenaces para lograr esa conservación consistirá en combatir las plagas y enfermedades de los árboles de los bosques y para eso los patólogos agrícolas y forestales mexicanos cuentan ya con laboratorios de investigación y campos para experimentaciones, que les permiten llevar a cabo estudios ecológicos integrales que conduzcan al buen resultado de ese propósito de defensa.

En México son numerosas las plagas de insectos que atacan a los árboles. Entre ellas se mencionan como las más importantes, en primer lugar los Coleópteros, luego los Lepidóteros y después los Himenópteros. Otros órdenes de insectos tienen en realidad escaso interés desde el punto de vista de los perjuicios que causan.

Entre los insectos Coleópteros de la familia de los Escolítidos, reportados en México como plagas de las Coníferas, se mencionan los de los géneros Phloeosinus, Dendroctonus, Ips, Gnathotrichus, Platypus, Tesserocereus, Scolytus, Hylastes, Hylurgops y algunos otros, que atacan a diferentes especies de Pinus en los bosques del centro del país, en los Estados de Puebla, México, Michoacán. Morelos, Hidalgo, Guerrero y en el Distrito Federal.

De todos esos géneros, el Dendroctonus es seguramente el que mayores daños causa. Estos insectos, llamados "descortezadores" en lenguaje común atacan principalmente a los árboles de los géneros Pinus, Picea y Abies, que existen en los bosques de Amecameca y Chalco, del Estado de México, en los del Estado de Chihuahua, en la misma ciudad de México, en el Estado de Michoacán, etc.

Las especies Dendroctonus mexicanus y D. parallelocollis ocurren principalmente en los bosques de Amecameca, en los del Estado de Michoacán, en Tacubaya, D. F., en Jonacatepec, Estado de Morelos y otras regiones, atacando los Pinos. La especie

D. valens es la más ampliamente distribuída y ataca a los árboles Pinus, Picea y Abies antes mencionados.

Otros parásitos de los bosques en México consisten en dos -"moscas"del órden de los Himenópteros, que atacan las agujas de -los Pinos y son, el Neodiprion vallicola y el N. banksianae. Entre los Lepidópteros se ha encontrado una pequeña mariposilla --que ataca a las Coníferas: es la Moctezuma cardinalis.

Respecto a plantas parásitas, la que principalmente afecta a muchas especies de árboles en una extensa región del centro de México es la llamada "muérdago" (Dwarf Mistletoe), del género -Arceuthobium. En los Estados Unidos hay cinco especies de este-género de la familia de las Lauranciáceas y cuatro de ellas también se encuentran en México, una de las cuales es la A. vaginatum que ataca exclusivamente a los pinos de 3 agujas, causando -considerables pérdidas en montes de Pinus contorta y P. banksianae.

En cuanto a enfermedades fungosas y bacterianas se han es--tudiado algunas de los bosques de México, pero no ocasionan se--rios perjuicios en lo general. Comunmente se les da más importancia a las que atacan a los árboles frutales, en los cuales es -más fácil y costeable combatirlas.

Las enfermedades fungosas consisten en Phytopthoras, unas -que producen la "pudrición del cogollo" o la "marchitez de la --hoja", Pestalozzia; la "herrumbre" (Uromyces sp.) , la "mancha -de la hoja" (Cercospora sp.), la "antracnosis" (Gnomonia sp.), -etc.

Esto es, en brevísimo e incompleto resumen lo que México -cuenta con respecto a las plagas y enfermedades que afectan a -sus bosques.

Concretamente en lo que se refiere al Pinus ponderosa, que tanta importancia tiene en el suroeste de los Estados Unidos, vegeta también en México; hay bosques de esta especie en los Estados de Baja California (Sierra de Juárez y San Pedro Mártir) y -en el Estado de Chihuahua, extendiéndose hacia el sur de esta última entidad hasta el Estado de Durango. Siendo limítrofes Baja -California y Chihuahua con la zona suroeste de los Estados Unidos en donde vegeta el Pinus ponderosa, caracterizadas las dos por iguales o semejantes condiciones ecológicas, es muy posible que -a la especie de referencia la afecten las mismas plagas y enfermedades.

Por lo tanto, cuando fuí atentamente invitado por el señor Dr. Lake S. Gill para asistir, en mi carácter de Presidente de la Sociedad Forestal Mexicana, a esta IV Conferencia Internacional para estudiar los problemas originados por las plagas y enfermedades de los bosques, me interesó extraordinariamente lo que aquí debería tratarse y este es el motivo de que ahora tenga el alto honor de encontrarme con ustedes para aprender mucho de lo que en esta reunión van a dar a conocer como expertos que son en la materia.

La Sociedad Forestal Mexicana y asimismo tres importantes y progresistas empresas de la industria forestal de México, productoras de papel, como son las Fábricas de Papel Loreto y Peña Pobre, S. A., situada en la ciudad de México, las Fábricas de Papel de San Rafael y Anexas, S. A., en el Estado de México y la Cía. Industrial de Atenquique, S. A., en el Estado de Jalisco, cuya representación tengo acreditada ante esta Conferencia, saludan a ustedes por mi conducto con sus mejores deseos porque esta (esta) Asamblea adopte resoluciones acertadas y provechosas para la mejor conservación de la sanidad de los bosques, cuya existencia es y será por siempre indispensable para salvar de la destrucción otros recursos renovables, como son la tierra y el agua, factores todos ellos fundamentales para mantener el equilibrio maravilloso de la Naturaleza.

Summary by Tom Gill of the Pack Foundation

The history of forest pathology in Mexico is traced from 1869 onward. Not until 1900 was there a serious, methodical attempt to collect data and study the principal tree enemies, especially Arthropoda and some fungous and bacterial micro-organisms.

In 1918 the National Forest School was founded, with a division of Forest Parasitology under the direction of Ing. Riquelme. Since then various organizations, public and private, have amplified knowledge in this field.

In Mexico there are many insect infestations, the most important of which are the Coleoptera, next the Lepidoptera, and after that the Hymenoptera. The Dendroctonus is the most destructive of all. Fungus and bacterial diseases have been studied, but do no great damage. Among plant parasites, the dwarf mistletoes of the genus Arceuthobium attack many tree species over a wide area.

ECOLOGY AND FOREST DISEASE RESEARCH

by

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Introduction

Some concepts presented in this paper may be considered unusual by many forest pathologists, and possibly contrary in part to the evaluation attached to host-pathogen associations. One purpose of this approach is to promote discussion and another to outline some objectives and an appraisal of the results to be obtained from incorporating physiological and ecological considerations in forest disease research. If the opinions expressed are reasonable it follows that the approaches to many disease problems are subject to review and revision if pathologists are to be of the greatest value to forestry and obtain the confidence of the forest operator.

Orientation

The theme topic for this Meeting is interpreted to include the influences of ecological factors upon the development of non-infectious and infectious diseases. Ecology and disease have been defined as follows by the Society of American Foresters:

> Ecology - The science which deals with the relation of plants and animals to their environment and to the site factors that operate in controlling their distribution and growth.
>
> Disease - The injurious unbalancing of normal functions, often as the result of attack by a pathogen, and of sufficient duration or intensity to cause disturbance or cessation of vital activity.

The definition of ecology implies that differences in tree distribution and growth occur because of variations in environment and site which affect the physiological processes of tree growth. In some areas growth is good, in others poor, but itis important to recognize that good areas are not referred to as normal and the poor areas as abnormal. Further, the definition for ecology would appear to cover the pathologist's approach to a non-infectious disease problem with the important exception that a pathologist may refer to the poor areas as disease areas implying abnormal conditions and the desirability of preventative or control measures.

The definition of disease is most difficult to interpret because as a prerequisite it requires a basic knowledge of the normal functions of tree and stand growth and development. At the present time is there an understanding of the normal functions of growth for any one of our commercial tree species? If not, how is it possible to establish injurious unbalance?

It is believed that our present lack of knowledge of the normal functions for tree growth has and will lead to conflicting opinions into the origin and importance of forestry problems related to tree growth and survival. The ecologist may explain poor growth and survival in some areas on the basis of unfavorable environmental or site conditions, or on the successional development of forest stands. These conditions are regarded as normal for the tree species occurring in these ecological types. A forest pathologist may classify these same areas as heavily diseased because of the occurrence of organisms on the trees and report to the effect that these organisms are the primary cause for poor growth and mortality. Reports on these host-organism associations infer that diseases are resulting in the injurious unbalancing of normal functions, indicating that some form of direct control may be desirable. At this point full consideration should be given to the Forest Manager and his problems in interpreting the divergent views which may be expressed by an ecologist and a pathologist on the condition of one forest area.

Host-Organism Associations

Frequently in forest disease research very little attention has been given to the physiological and ecological factors which affect tree vigour and predispose trees to infection by universally-present, indigenous organisms. Many of the studies provide positive evidence of attempts to describe diseased conditions (or the injurious unbalancing of normal functions) failing to provide for the essential prerequisite of establishing what is normal for the tree species on the areas concerned. The literature in forest pathology contains innumerable references to host-organism associations or diseases which are reported to be of light, medium, or heavy intensity based upon the frequency of the associations. This type of information has served as a common introduction to problems and has been the basis for the detection phase of forest-disease surveys. However, in many instances, a re-examination of the same diseased areas at a later date leads one to question the value of the earlier disease records and, indeed, the significance of these diseases on the growth and survival of forest stands. A few examples may be helpful at this point.

In a poplar nursery at Vancouver, black cottonwood has been observed to be highly susceptible to *Melampsora* leaf rust. Despite the heavy incidence of this fungus on the foliage this species has shown superior growth to adjacent trees of related clones which are highly resistant to the disease. There would appear to be no doubt that *Melampsora* is causing an abnormal disturbance to the normal functioning of the foliage of black cottonwood as evidencedby the heavy disease attack. The intensity of the rust on black cottonwood could lead to the recommendation that the continued propagation of this species should be abandoned in favor of more resistant clones. However, because of the superior growth of black cottonwood it would appear that an evaluation of the importance of the disease is dependent upon more than the frequency of the host-organism association. In this instance it would seem that disease appraisal is dependent upon a determination of the physiological and ecological characteristics of the host. If the foliage is functional to a limited extent when heavy rust infection occurs, the disease may be of limited importance.

In 1946, an examination was made of a plantation of Douglas fir reported to be infected by Rhabdocline in the Vancouver area. The diseased trees were located and it was noted that highly resistant trees occurred adjacent to the diseased individuals. The trees were re-examined in 1956 and it was evident that the fungus had continued to infect the trees previously classified as susceptible and not those noted as being resistant. Despite the fact that the foliage appears thin on the diseased trees, these trees are now taller and of a larger diameter than the adjacent resistant trees. This would appear to be another instance in which it is difficult to appraise the importance of the host-pathogen association in terms of tree growth and survival. Studies on the normal physiology and ecology of needles of different ages would seem to be a necessary prerequisite to a more complete understanding of the disease.

The examples given lead one to doubt whether it is correct to regard all host-organism associations as diseases which adversely affect the growth and survival of trees. The established concepts of the injury and damage from foliage diseases (reduced increment and mortality) are upset by these findings. On the basis of measurements there is evidence to suggest that some host-organism associations may be beneficial rather than harmful to tree growth. It would seem that because an organism is infectious on a host it cannot be assumed that it is adversely affecting tree growth and constitutes an undesirable condition in forestry. In general, is it possible that forest pathologists have overemphasized host-organism associations without considering their relation to the physiological and ecological characteristics of tree and stand growth and survival? It would seem, therefore, that the function of a forest pathologist involves considerably more than establishing the infectious nature of an organism on a host and stating its importance on the basis of the frequency of the association in trees or stands.

The Research Specialist in Forestry

Possibly the finest stimulus that the research specialist in forestry could acquire would be gained from reading and studying a number of the earlier writings in forestry. Foresters as Fernow, Von Shrenk, etc. were excellent naturalists and observers who after examining a forest area were capable of giving sound advice on the forest as a whole. It was recognized that the forest was a biological complex with many interrelated, influencing factors. Further, disturbances occurred in the complex but not necessarily in a direction which was detrimental to good forestry. The presence of disease-causing organisms was recognized but it was also appreciated that these organisms may be beneficial as well as harmful to good forest practice.

Unfortunately the forester with a broad perspective of the forest and its problems would appear to have disappeared for the most part. The age of specialization had delegated forest research problems to many different disciplines which frequently operate independently. In recognition of the need for research coordination attempts are made for the specialists to meet on occasion to discuss programs underway. The value of these meetings may be questioned since effective coordination involves research in its planning as well as reporting stages.

From experience it was concluded that there is an urgent need for more forest pathologists that have the vision to examine a research problem in its entirety. On occasion it would appear that the approaches to disease problems would become unduly confused through fears of inaptitude or becoming involved in studies which may be regarded outside of the scope of a forest pathologist. Is it possible that specialization in some instances has over-ruled common sense? Until recently perhaps forest ecology in relation to forest disease reseach would fall within this category.

<u>The Scope of a Forest Disease Problem</u>

It has been argued that some of the objectives of a forest pathologist and tree disease research may be open to question and that our efforts should be broadened if results are to be obtained which will be of the greatest value to forestry. Further, it is considered that the field of forest ecology may be related to forest disease research. However, it is most difficult to discuss the two fields either jointly or independently without some consideration into the parts they play in the broad field of forest research.

Kleb, a German physiologist of the 19th Century advanced the following concept which, it is believed, outlines the basis for forest research in a brief and straightforward manner:

<u>Heriditary Factors of Trees</u>	<u>Environmental Influences</u>
Forest Genetics Resistance Studies etc.	Forest Ecology Forest Soils etc.

↓

Tree Anatomy and Physiology

↓

Tree Growth and Survival

Forest Mensuration

Forest Utilization

Forest Pathology

etc.

In accordance with this chart problems in forestry begin at the genetic and environmental levels leading into the different anatomical and physiological processes which affect tree growth and survival. It is accepted that heredity, environment and physiological processes affect tree growth. However, have the effects of these factors on the presence or absence of disease-causing organisms been accepted in full measure? Is it not possible that the importance of a disease has been explained on the basis of the frequency of a host-organism association without investigating the problem beyond that point? In some instances, it would appear that the factors outlined in the chart have been considered in reverse in determined attempts to prove that infectious diseases are the primary cause for stand losses. Indeed, the literature in forest pathology provides examples of large scale efforts with inconclusive results to establish the presence of an infectious disease as the primary cause for a reduction in tree growth and mortality. Later efforts to solve these problems provide evidence that the host-organism associations are simply signs of maladjustment in the more basic factors which govern tree growth.

Hereditary Factors in Relation to Diseases

From an examination of the chart it is evident that the presence and severity of some diseases may be explained on genetic grounds and after consideration of this possibility the ecological influences may be investigated. It has been demonstrated that the genetic make-up of the host is a determining influence in the susceptibility or resistance of trees to a number of obligate or near-obligate parasites. Further, within our experience evidence is available to demonstrate that some individuals of a tree species may be resistant to endemic diseases which are caused by facultative parasites. Therefore, it would seem of importance to separate the influences of genetic vs. ecological factors when explaining disease intensity. This problem becomes very complex when it is appreciated that natural hybridization is occurring freely in many tree species. It may be of interest to enquire whether adequate consideration has been given to the possibility of genetic differences in the host, in the research objectives outlined for disease projects giving emphasis to ecological influences.

Ecology in Relation to Tree Diseases

The forest pathologist is aware of the work of forest ecologists in classifying forests on the basis of vegetation types, soil profiles, etc. Indeed, such classifications provide the pathologist with a basis for further research to correlate the incidence of a host-organism association with site. In some instances disease reports have outlined a very close relationship between the occurrence and intensity of a biological organism and the different ecological types of a tree species. Some relationships have been so precise that it is felt that the relative abundance of a biological organism could serve as a reliable site indicator for the forest ecologist. Yet it would appear to be uncommon for the ecologist to use host-organism associations for this purpose.

Is it possible that the present situation has arisen as the result of differences in emphasis and definition for the two fields of study? As has been mentioned the pathologist may interpret a host-organism association as harmful and causing abnormal disturbance to the forest. The ecologist may regard the same host-organism association as normal for the areas concerned and a necessary part of the succession of tree species to climax types. There would appear to be an urgent need for greater coordination between pathologists and ecologists to arrive at a proper understanding of the importance of many of our host organism associations and their potential impact on forest management. It is unlikely that this will be accomplished if it is inferred that all host-organism relationships are diseases which result in abnormal damage and loss.

It would appear that only recently did forest pathologists give serious thought to the importance of ecological and physiological factors which may predispose trees to heavy attack from indigenous organisms. A review of the approaches made on Birch Dieback and Pole Blight would appear to confirm this belief. The first approach to most problems would seem to consist in placing full emphasis on locating an infectious organism as the primary cause of the disturbance. After considerable effort and expense in this direction, studies are undertaken on the basic physiological and ecological factors which may affect the growth of the trees. The results of these studies suggest that the host-organism associations initially thought to be of primary importance may serve only as indicators or factors contributing to the real causes of the problems.

Assuming that there is general recognition of the importance of ecological and physiological factors in predisposing trees to host-organism associations (diseases) are we convinced of the need of investigating these as a first rather than a second approach to disease problems? Further, is it possible that the importance of many diseases is not in the volumes affected or killed, but in their varied intensity in different areas indicating sites or conditions which require differential treatment for good forest management?

FOLIAGE DISEASE ECOLOGY

J. L. Mielke

Dr. Dow V. Baxter mentions in his pathology text that a fundamental principle in the control of endemic diseases is to prevent sites from deteriorating and to hold potentially destructive organisms to a low level in the forest by cultural practices.

According to Dr. J. S. Boyce, most epidemics of native pathogens arise when a host is weakened by some unfavorable condition. Epidemics of native pathogens do not 'just happen'. There is always a basic reason. He states: "Conditions in natural stands point strongly to the fact that there is no factor more important in relation to disease than tree vigor. Stands on good sites are generally not damaged significantly by native diseases, but those on poor sites often suffer severely. The destruction of normal forest conditions can lead to such profound changes in site that on the less favorable locations it may be impossible to establish again a satisfactory stand of the climax species for decades, even by planting".

Heiberg and White, in the January 1956 issue of the Journal of Forestry, state: "Site is not static; it is dynamic. Frequently site factors can be influenced through silviculture. Site varies from period to period, from year to year, and man influences site greatly. True there are basic climatic and edaphic factors over which man has little influence, but through cutting, slash disposal, control of fire, grazing, and other activities, man has great influence upon the productive capacity of a given site".

Elytroderma deformans - Blight of ponderosa pine

I believe that the Elytroderma blight of ponderosa pine is a good example of a disease that became epidemic because of changed environmental conditions for the host. Disease destructive only on certain areas.

Sites - Elevation
Fire climax - not ecological climax
Mostly overmature stands
Growth rate of trees, particularly second growth
Bark beetles
Fire protection
Sheep grazing
Changed climate - less precipitation
Root rots
Effect of high temperatures on ascospore production
Ascospores germinate at relatively low temperatures

Hypodermella concolor - Needle cast of lodgepole pine

Epidemic started about 1946 or 1947 on the Garghee N. F.
Fungus now known on 9 national forests in Region 4 - probably more widespread.
Environmental factors involved in epidemic not known.
Occasional resistant tree.

Rhabdocline pseudotsugae - Needle cast of Douglas fir

Destructive flare-up on Cache N. F., Utah, in 1950. Killed some pole-sized trees.Little known about the ecology of this fungus. Disease destructive only on local areas.

Marssonina populi - Leaf and twig disease of aspen

Very destructive on Cache N. F., in 1948 and 1949
Epidemic again in 1952
Flare-up in 1956
Relative susceptibility of clones

Some Ecological Aspects of a Suspected Needle Cast of Ponderosa Pine

by

Stuart R. Andrews

According to local Forest Service personnel needle dieback of ponderosa pine was first noted in 1947 on the Prescott National Forest. The dieback apparently was limited to an area of less than 100 acres in a draw forming the headwaters of the Hassayampa River on the Prescott District of the forest.

Dieback was evident on practically all trees in the center that was located along the edge of a 75-year old even-aged stand--the prevailing stand of the Prescott District. The dieback was most obvious in late spring when the center appeared fire scorched. By late summer, however, the stand had resumed nearly normal appearance because most old brown needles had been shed, and the newly developed needles were still green.

Severely affected trees had only current year's needles, which were usually thin and short. Subsequent examinations have indicated that chlorotic flecks appear on these needles during the winter months and they start dying back from the tips. Moderately and more recently affected trees had 2 or 3 to almost the normal 5-6 year complement of needles, but all excepting the current year's needles showed varying stages of dieback. Lightly affected trees were difficult to recognize except by what passed for premature or abnormal needle shed.

The center at Hassayampa Lake was examined periodically by the Forest Service from 1947-1953. The seasonal development seemed to be the same each year. By 1953, however, it was obvious that the affected area had increased. It extended up the adjacent slopes, around the shoreline of Hassayampa Lake, and along several roads that radiated out from the original center. This spread, rather than indications of permanent damage, led to submission of specimens to entomologists and pathologists in July 1953. Laboratory examinations were inconclusive.

Dieback was inspected by a pathologist in July 1954. A number of trees were examined but no pathogenic fungi were found. Although _Elytroderma deformans_ is endemic on ponderosa pine throughout Arizona and New Mexico resin cysts, a dependable symptom of _Elytroderma_ needle cast, were observed only on occasional trees having characteristic witches'-brooms. A suspected new outbreak was observed at the head of Crooks Canyon. It was near to but not contiguous with the Hassayampa Lake center. Additional examinations were made in 1955, still without noting any suspect pathogens. It was obvious, however, that the two centers were continuing to increase, and the Hassayampa Lake area was estimated at 1,200 acres. At this time, it was believed that needle dieback probably was the expression of a complex ecological or physiological disturbance.

Examinations were continued in August 1956. Fruiting bodies of several fungi were seen for the first time, but they were not abundant. Laboratory examinations, however, revealed a striking development of needle-inhabiting fungi since collection. During the August examination, new centers of dieback were found in Turkey Creek, Big Bug Mesa, and Mingus Mountain. Additionally, 4 suspicious areas (Stoneman Lake, Munds Park Road west of Mormon Lake, Allan Lake, and Baker Butte) that had been reported by the Coconino National Forest were examined and found to be similar if not identical with the outbreaks in the Prescott National Forest. Suspected needle cast or dieback areas were mapped by entomologists during the 1956 Aerial Insect Survey.

Diseased material collected in August 1956 was submitted to the Plant Disease and Epidemic Section of A.R.S., and the needle cast fungus *Hypodermella medusa* Dearness was found in a Hassayampa Lake collection. It is obvious however that a number of other fungi may be present.

The areas of suspicious dieback centers, as estimated from the ground and from the results of the Aerial Insect Survey are as follows:

1. Prescott National Forest

Hassayampa Lake ----------------	1,500 Acres
Crooks Canyon ------------------	300 "
Turkey Creek -------------------	not mapped
Big Bug Mesa -------------------	500 Acres
Mingus Mt. ---------------------	300 "

2. Coconino National Forest

Stoneman Lake ------------------	700 Acres
Munds Park Road ----------------	1,600 "
Allan Lake ---------------------	2,500 "
Baker Butte --------------------	5,500 "

To date mortality associated with needle cast has been negligible. There can be little doubt, however, but that affected trees are predisposed to attack from other harmful agencies because of reductions in vigor resulting from needle loss.

It has been assumed that the effect of ponderosa pine needle cast on vigor and growth at Hassayampa Lake will be difficult to assess because it is superimposed upon the effects of the current drouth. This assumption seems reasonable, because the Prescott National Forest has always been considered marginal, presumably for lack of adequate precipitation. Several trees that were dissected had been growing slowly for the past 10-12 years. The objective of this paper is to report what I have found in attempting to confirm or deny this assumption.

Inasmuch as we now have strong implications that dieback is an infectious needle disease, my main interest has been the extent to which the Hassayampa Lake area has been deficient in moisture. The nearest Weather Bureau Station is at Groom Creek, probably 500-1,000 feet lower than the lake. As a basis of comparison, Flagstaff, Arizona, was selected because it is recognized as being fairly representative of the productive interior ponderosa pine region of the Southwest. Since 1950, the Flagstaff weather station has been located at the Municipal Airport and is definitely in the forest from a climatic standpoint. A partial comparison of precipitation records for the 2 stations is given in Table 1.

For the 6 years, when totals were recorded at both stations, precipitation was greater at Groom Creek than at Flagstaff every year, and apparently was significantly greater in all but one of the years (1948). Similar differences in favor of Groom Creek are evident in the records of precipitation for July-Sept. combined. In all but one year (1949), summer rains were heavier at Groom Creek, and they were probably significantly greater in at least 7 years (including 1952-1956). Furthermore, in at least 5 years summer rainfall at Groom Creek could hardly be considered characteristic of a drouth period. Less differences were evident in late winter and spring precipitation, but April rainfall in 1951, 1952, and 1955 at Groom Creek exceeded that at Flagstaff by 0.6-1.1 inches.

This limited analysis suggests that conditions for a build-up of needle cast or another needle disease may have been more favorable at Hassayampa Lake than might be assumed from the records of an extended drouth in the Southwest.

Table 1.--Precipitation at Flagstaff and Groom Creek, Arizona

Year	Total: Flagstaff (in.)	Total: Groom Creek (in.)	July-September: Flagstaff (in.)	July-September: Groom Creek (in.)
1946	21.8	-	9.77	11.52
1947	13.1	-	6.10	8.44
1948	15.4	15.7	3.88	4.07
1949	26.5	-	7.47	3.58
1950	-	-	-	8.78
1951	25.8	28.3	10.57	11.35
1952	20.1	26.0	7.11	11.30
1953	12.8	20.4	6.83	15.78
1954	19.4	25.5	8.18	11.75
1955	18.0	28.8	7.22	15.56
1956	-	-	2.63	5.86

FACTORS AFFECTING DISTRIBUTION OF NEEDLE BLIGHT

by John Hunt

Needle blight, caused by Elytroderma deformans (Weir) Darker, is a native disease of our western yellow pines. Lightle reports it as having been found on the following species of pine: jack, lodgepole, shortleaf, pinon, Jeffrey, and ponderosa. So far as I know, research and management have been confined to ponderosa pine, probably because this is the most widespread of the hosts, it has the greatest commercial value, and it is the species on which most of the damage has occurred.

The present outbreak is not the first to have been recorded. Weir described a severe outbreak of needle blight in 1913-1914, and his paper entitled "Hypoderma deformans, an undescribed needle fungus of the western yellow pine" contains the original description of the species. Other less severe and local outbreaks have also been recorded. The present outbreak first came to the attention of forest pathologists in the early 1940's. It is still with us in 1956 and is by far the worst outbreak on record.

Quite a bit of research has been done during the last ten years. Paul Lightle studied the pathology of the fungus, and his results are reported in Phytopathology, 1954. Many of his results do not agree with those reported by Weir in 1916. Toby Childs is carrying on a research program with emphasis on the damage aspects of the problem. Permanent plots have been laid out, both in mature timber and in pole-sized timber. Childs' results to date are summarized in the Pacific Northwest Forest and Range Experiment Station Research Note No. 114. Lew Roth has started work on the epidemiology of the fungus, but his studies are still in the preliminary stages, and he has nothing to report.

With that brief summary out of the way, we now come to the phases of work reported here, namely, survey and associated studies. By 1955, damage estimates made on the permanent mature tree plots were considered sufficiently reliable to be used as a basis for the development of survey techniques. Strip surveys were used during most of the 1955 field season and these proved satisfactory for damage estimates. This method permitted fairly rapid coverage of large areas. However, the estimates were too subjective, and

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the unavoidable lumping of different environments made it difficult to evaluate, even approximately, the various factors affecting occurrence of the disease. So, during the latter part of 1955 and in 1956 we used small temporary sample plots immediately adjacent to the road. These plots are usually about one acre in area, and one-quarter to one mile apart, but vary somewhat in area and distribution, depending on the adequacy of representation of the various size classes of pines and the intensity of sampling considered necessary.

On each plot, all of the overstory pines plus enough of the understory to furnish an adequate basis were tallied by size classes (P_1, P_2, P_3, and P_4) and infection class (none; trace, less than 1 percent of the twigs infected; light, 1-20 percent; moderate, 20-50 percent; heavy, 50-80 percent; and very heavy, 81 percent or over). Forest type, elevation, topography, and aspect were also recorded. This method is a little slower than the strip method, but is probably more accurate for determination of local disease intensities, and is more useful in analysis of relationships between the environment and the disease. For each plot, an average infection value was computed, using standard values for each of the infection classes. For example, trees with 1 to 20 percent of their twigs bearing blighted foliage are classed as light and are assigned a standard value of 10 percent for computation purposes. Altogether, 711 different plots were taken during 1955 and 1956. To check 1955 and 1956 work, 54 of the 1955 plots were resurveyed in 1956. The mean difference between the two sets was not significant.

Briefly, needle blight occurs throughout the region, varying from rare to abundant. The disease appears to be most common and damaging in the Blue Mountain province of Oregon within a roughly triangular area bounded by lines connecting Prineville, Vale, and Pendleton. In the Wallowas, blight is most common to the south, east, and northeast of Enterprise.

One of the major unanswered problems with regard to needle blight outbreaks is what factor or combination of factors are associated with the sudden buildup of needle blight? It was to get at some of the environmental factors involved that we used the small temporary sample plot method of survey. As I mentioned earlier, in addition to blight intensity we recorded forest type, elevation, topography, and aspect on each of our plots. An analysis of the above factors gave us negative results on all but elevation. Having reported this I could sit down and leave it at that, but perhaps a few comments on what was done and the results we obtained are in order. Undoubtedly each of you will have ideas and suggestions which will lead us back to the straight and narrow path of positive and highly significant results.

<u>Elevation</u>. Since the beginning of the current blight outbreak, foresters have observed that infection within a given locality tends to be most severe at one elevation, usually about 5,000 feet, and that the

abundance of the disease decreases with either increasing or decreasing elevation from this level. This observation has been confirmed by our sample plot data. A sharply defined maximum occurs at about 5,200 feet. I am not prepared to give you an interpretation of this phenomenon. However, it appears to me that elevation, which may reflect climatic conditions such as temperature and moisture, certainly is an important factor in the distribution patterns of needle blight. Since the effect of elevation is so pronounced, all plots were adjusted to a common elevation and the significance of the other factors was tested. As I mentioned earlier, none of them was significant.

<u>Forest type</u>. Plots were taken only in pine types. Although there is variation between types, no pattern emerges to give us any clues as to the effect of type on the distribution of needle blight.

<u>Aspect</u>. For every plot tallied, an aspect was assigned, using one of the eight points of the compass, or in the case of level areas, none. Again no pattern emerges which would give us any indication as to the effect of aspect on the distribution pattern of the disease.

<u>Topography</u>. We divided topography into seven general classes, and then subdivided some of the general classes, so that altogether we had 15 categories. Topographic categories which have above-average infection are level, edge of meadow, wide draw, and lower gentle slope. Those categories conspicuously below average are steep slopes, upper slopes, and ridges. Is it possible that air movement may have some effect on needle blight infection and consequent distribution? Another clue along this line of reasoning is the value for each of the slopes--lower, middle, and upper. Infection percentages generally decrease from lower to upper slopes. No definite conclusion can be obtained from these data, but they are suggestive. It is possible that we have narrowed our topographic categories into units which are too small and that we should be dealing with larger discrete topographic entities, such as the head of a draw, a small valley, or the upper part of a drainage.

Concluding this discussion, it is apparent that so many interactions exist between the environmental factors affecting the distribution of this disease that it is impossible to untangle them with the information now available. Nevertheless the distribution patterns of the disease as revealed by our survey would suggest that the abundance of blight is largely determined by prevailing weather patterns during the infection period, and it is probable that many of the local irregularities in abundance are a result of modifications caused in these weather patterns by local landforms.

FOLIAGE DISEASE ECOLOGY - Panel

Summary of Discussion

James L. Mielke

Elytroderma Blight of Ponderosa Pine

Considerable discussion followed John Hunt's paper on this subject. The fact was brought out that the disease still presents many puzzling problems. Factors such as site, possible climatic changes, changes in the environment of the disease areas, elevation, individual tree susceptibility, vigor of the host, etc., appear to be involved and need evaluation. The life history of the fungus is still imperfectively known, also the conditions necessary for infection of the pines. Studies are needed on the role of the pycnidiaspores in the epidemic. It was brought out that in Oregon and Washington mortality associated with the fungus is no greater than that from dwarfmistletoe, windfall, root rots, etc. Saplings and poles are about twice as severely affected as the older trees. The possibility of "single tree approach" instead of conducting studies on an area basis was suggested. This discussion brought out that differences in susceptibility of individual trees might limit the value of the individual tree approach method.

"Arizona" Blight of Ponderosa Pine

Following the showing of colored slides and a description of a foliage blight of young ponderosa pines ranging in size from saplings to second growth there was considerable speculation by members as to the possible cause of the disease. Affected areas are on the Prescott National Forest in Arizona. Although *Hypodermella medusa* developed on some affected needles, it was brought out in the discussion that this fungus evidently is not the primary cause of the needle killings. *H. medusa* attacks only the older needles, whereas in this case all ages of needles present were affected. It was also pointed out that the affected trees were not typical in appearance to ponderosa pines attacked by *Elytroderma deformans*, which fungus attacks the current season's needles. The opinion seemed to be that some physiological disturbance possibly was associated with the blighted conditions of the pines.

THE ECOLOGY OF WHITE PINE BLISTER RUST
By H. R. Offord

DEFINITIONS AND SCOPE OF THE PROBLEM

For purposes of this topic on the panel it will be helpful to define ecology in the general terms used by botanists as dealing with "mutual relations between organisms and their environment." Moving a step further in focusing our attention on the ecology of white pine blister rust, but still setting the problem within the framework of ecologic terms, we can state that we are concerned with the phenomena of aggregation, migration, and ecesis. The latter term is defined as "the adjustment of the plant to a new home" and involves the processes of germination, growth, and reproduction.

Now the brief definition of ecology that I just used is a particularly happy one in discussing the ecology of blister rust because of its emphasis on "mutual." Since the rust is heteroecious, we must recognize the pine, the ribes, and the pathogen as a group of three biologic entities each of which has its own manifestations of aggregation, migration, and ecesis. Continuity of favorable sequences of weather factors determines response of the pathogen. Wagener has pointed out the significance of this factor in reporting the development of Cronartium commandrae. In point of fact, research on pine, ribes, and the pathogen have usually been done by people trained in three different disciplines--silviculture, botany, and pathology. Thus the complex biology of the inter-relationships of three organisms is further complicated by the fact that we could have people with three different viewpoints working on the several phases of the problem. As practical technicians we are primarily concerned with points of departure between requirements of ribes and white pine working towards the final objective of reducing the rust to the status of a minor forest pest.

In view of the vast amount of research that has been done on white pine blister rust it is surprising to find that control supervisors are still puzzled by many aspects of rust behavior. Suppose we consider for a moment some of the questions that field supervisors and research workers often ask about the ecology of rust, ribes, and white pine.

WHAT DO WE NEED TO KNOW ABOUT ECOLOGY OF RUST, RIBES AND PINE?

1. Are we dealing with uniformly hazardous rust conditions in the various "local control" or "unit control" areas of a single region and pine species?

2. Can we develop a rust hazard index or meter to guide us in planting, managing, and protection of white pines?

3. Can we prescribe control standards (ribes populations) and sanitation schedules on white pine that will be based on a reliable appraisal of ribes and pine ecology?

4. How far and from where is pine infection coming?

5. In cutting white pine stands how does the volume and pattern of improvement cuts or the size of clear cuts affect rust hazards and cost of protection?

6. During regular checking (sampling) procedures should we attempt to classify individual ribes as to rust potential and regenerative vigor as a basis for directing subsequent eradicative effort to micro ecologic niches from which fertile sporidia are most likely to be disseminated?

7. Can we intensify our search for rust resistant pines by eliminating those that are escapes because of unfavorable local climate?

8. What is the annual increment of cankers on sugar pine branches of various sizes and how does this growth rate vary over the latitudinal range of the species?

9. What differences exist between the requirements of white pine and ribes for regeneration and optimum growth?

10. How about rust races, facultative adaptation, and the principal of minimal numbers in ecesis of rust and ribes?

Let's look briefly at some of the problems of rust behavior as they affect control work in sugar pine type.

SOME ASPECTS OF RUST BEHAVIOR AFFECTING CONTROL WORK IN SUGAR PINE TYPE

Substantial evidence exists to show that:

(A) Rust behavior and consequently rust hazards vary significantly over sugar pine acreage now delimited for control in southern Oregon and California. This evidence becomes clearer as we move south down the Sierra Nevada of California.

(B) In westside Sierra Nevada of California temperatures and rainfall vary significantly from one year to another.

(C) Topography and ground cover have a marked effect on the incidence and intensification of the rust.

In California we have initiated a more rigorous policy of "local control" designed to capitalize, insofar as safety permits, on the experience noted in (A), (B), and (C) above. We find, however, that we need to pinpoint our understanding of climatic factors that restrict or intensify rust spread. The recent work of Van Arsdel and Riker in Wisconsin stimulated interest in these so-called microclimate studies. Similar work has been under way at the California Station by Robert Bega both in the field and in controlled chambers in the laboratory. One objective of Bega's work is to check the findings of the Wisconsin workers with respect to California species of pine and ribes. Once we know what to look for with respect to the range and duration of the factors and topographic features that are restrictive or helpful to rust spread and intensification, we should be able to:

(1) Make better use of records from established weather stations and of maps showing local topography and vegetation. (C. R. Quick completed an exploratory study on the estimation of blister rust infection intensity by multiple regression analysis of selected habitat factors.)

(2) Prepare a more useful alignment chart (rust hazard meter or other type of practical field guide) for the appraisal of rust hazard and the establishment of adequate standards of ribes suppression.

(3) Schedule disease survey work at effective and economic intervals.

(4) Make more accurate long range predictions of anticipated losses from rust.

Actually the most perplexing questions that BRC supervisors have to answer are--"Where is the rust coming from?" "How much of the observed pine infection is coming from the residual ribes within the control unit and how much from undisturbed ribes outside the unit?" We all recognize that environmental factors can be critical and limiting at either the pine or ribes end of the cycle. Since both ribes and naturally established pine tend to be patchy in distribution, the total impact of microclimate is greatest when both ribes and associated pine are situated in favorable spots. At the other extreme the least hazardous association will be where both ribes and pine are in low hazard niches. Unfortunately we don't often encounter this clear-cut association of extremes under field conditions. The point is readily emphasized by reference to any simple 3-way stratification of rust hazards with the two principal variables of moisture and temperature, e.g., Rust Hazard and Spread from Ribes to Pine (Germination of telia, casting of sporidia, and infection of pine).

Rust Hazard of Site	Duration of Favorable Moisture	Temperature Degrees Fahr.
High	36-72 hours	55 - 62
Medium	18-36 hours	62 - 68
Low	Less than 18 hours	68 - 70 +

If we have a close association of a susceptible ribes and pine in a niche where moisture is abundant and persistent and cool temperatures prevail, there isn't much doubt about the certainty of recognizing this as a local spot having high potential for rust build up. Confusion lies in the many possible combinations of these nine items which tend to provide median readings because they are not mutually exclusive. The essential core of the problem is a precise definition of the limiting or restricting elements in each combination.

Epidemiology of Cronartium ribicola.

Now let us refer to the mimeographed tabulation that I have just handed out. This tabulation is based on a similar summary prepared by D. R. Miller in 1954 with some revisions on the range and restrictions pertinent to the several spore stages as indicated by recent studies of R. V. Bega.

SOME FACTORS OF MAJOR IMPORTANCE TO THE INFECTION OF PINE AND RIBES BY WHITE PINE BLISTER RUST

1. Aeciospore Germination

    a. Temperature (in degrees F.):

        Range: 39 to 75.2
        Optimum: 60 to 68
        Restriction: 90 for 36 hours
        Stimulation: Freezing or extreme heat (90-97) for 8 hours.

    b. Moisture: Saturated air (97-100 percent humidity) needed for initial discharge and germination of aeciospores.

    c. Time: 5 hours at 60 to 68. Longer period needed for lower and higher temperatures.

    d. Viability: Under fluctuating conditions in field 3 to 6 weeks. Under controlled storage conditions several months. Bright light (ultraviolet) plus temperature at 82.4 destroys viability.

2. Urediospore Germination

   a. Temperature (in degrees F.):

      Range: 46.4 to 82.4
      Optimum: 68 to 75.2

   b. Moisture: Humidity between 97 and 100 percent, preferably with free moisture on leaves.

   c. Time: 4 to 6 hours within temperature range of 46.4 to 82.4.

   d. Viability: For several months under special storage conditions. Under average field conditions for a few hours. Short periods of ultraviolet prevent germination.

3. Teliospore Production

   a. Temperature (in degrees F.): According to Van Arsdel and Riker, telia formed at constant temperature of 61.8 were viable and germinated well. Those formed at 75.2 were either inviable or slow to germinate. Teliospores formed at 68-75.2 may not be effective in spreading the rust because of the length of time needed for their germination. Freezing did not destroy the viability of teliospores.

   b. Time: According to Van Arsdel and Riker, two weeks of comparatively cool weather, preferably 60.8-68 or cooler, were needed for production of viable telia.

4. Teliospore Germination

   a. Temperature (in degrees F.):

      Range: 32 to 70
      Optimum: 60.8 (50 to 64)
      Restrictions: Below 32 and above 70

   b. Moisture: 97 to 100 percent humidity.

   c. Time: 11 to 12 hours.

   d. Age of telia: Best germination when telia are 4-9 days old.

   e. Viability: Several weeks.

5. Sporidia Germination

   a. Temperature (in degrees F.):

      Range: 32 to 70. Secondary sporidia are formed between 50 and 65.
      Optimum: 50 to 64.

b. Moisture: Best at 100 percent humidity. None of significance below 97 percent. Alternating drying and wetting decreased viability.

c. Time: For telia and sporidia to germinate 11 to 15 hours.

d. Viability: Minutes to a few hours after being cast, depending on environment. Hirt (1942) found some viable sporidia on glass slides kept at 58 percent humidity for 26 hours.

6. For Pine Infection under Field Conditions

Optimum: Cool weather (50 to 62°F.) for a period of two weeks while telia are forming. About 4 to 9 days after telia columns have formed fog, dew, or light rain (97-100 percent humidity) for about 12 hours, and then light rain for an additional 24 to 48 hours for pine infection.

7. Ribes Infection by Aeciospores

Optimum: Cool weather (60 to 68°F.) needed for 8 to 24 hours for discharge and germination. About 5 hours favorable temperature and moisture needed for ribes infection. Light rain followed by cool, cloudy weather with the humidity at 97 to 100.

8. Ribes Infection by Urediospores

Optimum: Best temperature range 68 to 75°F. Air saturated with moisture, fog, or dew on foliage for 4 to 6 hours.

Data provided in this tabulation are those that have appeared in the published literature of the epidemiology of *Cronartium ribicola*. They represent many years of work by an able group of specialists in the rust, Colley, Spaulding, Hirt, Hahn, Anderson, Mielke, Kimmey, Wagener, Riker, and Van Arsdel, just to name a few. We shan't take time here to go through this tabulation, but I do want to call your attention to items 3 and 4 on teliospore production and germination; here are some of the new concepts of Van Arsdel and Riker about the limiting effect of temperature. It is certainly a commentary on the complexity of this over-all problem to realize that control personnel are still short of information on rust behavior under the varying field conditions encountered in a large-scale control job.

Ribes and Pine

The phenology and physiology of the ribes host have an important bearing on incidence and intensification of the rust. We are concerned not only with variable ecologic niches where a single species may occur, but also with well-defined differences in reactivity to the rust by the several species making up the ribes population. Ribes bushes growing in the shade are usually in a micro-environment that is not subject to as wide a diurnal variation of light, temperature, and moisture as those in open, exposed sites. Leaf drop in the fall of the year is slower in the shade than in open, sunny exposures, especially if soil moisture in the shady locations is adequate as it usually is in stream type. Ribes leaf development in the spring of the year varies with species and with site, and this factor is of extreme importance in regard to ribes infection by aeciospores. Aecial production is generally less subject to seasonal variation than the growth activity of ribes. Thus sporulation of cankers may be out of step with ribes leaf development in some associations. Under westside Sierra Nevada conditions, perhaps this is one of the restrictive factors involved in the observed slow spread of blister rust from sugar pine sites at 4,000 to 7,000 feet into the high elevation sites where Pinus monticola and P. albicaulis occur.

Ribes species apparently vary in their capacity to keep the rust in its uredinal stage. Under eastern conditions Spaulding reported that urediospore production lasted about 120 days, an average for all species. R. nigrum usually maintained uredial production for about 185 days while R. lacustre had a much shorter period, about 65 days. Lachmund observed many years ago that urediospores are more effective than aeciospores for infecting ribes.

General aspects of ribes ecology in western white pine type and in sugar pine type have been fully described by Moss and Wellner, USDA Circ. No. 919, and by Clarence Quick, USDA Circ. No. 937. and by Clarence Quick, USDA Circ. No. 937. These reports cover in some detail the ecesis, aggregation, and migration of ribes with special reference to the impact of forest disturbances on ribes regeneration and the timing of control work. Eradication work in effect greatly accelerates the natural suppression of the "pioneer type" ribes in the maturing forest. But there is opportune time for scheduling this eradication work and a practical level of achievement to attempt at any specified stage in the ecologic development of the vegetation. Minimal numbers of host plants are of great importance in the rate of intensification. For example, Offord, Quick, and Moss, Jounr. of Agric. Res. (1944), pointed out the possible reduction in fruiting of ribes as they became more widely separated and reduced in numbers by eradication work. The limiting factor here is the self-incompatibility of the native ribes species involved. As practicing biologists we are concerned only with the effective distribution of the pest. D. R. Miller has observed that the presence of C. occidentale on ribes during a poor year for the spread of that pathogen is an excellent indicator of spots where C. ribicola is apt to be found later along the advancing front of spread for white pine blister rust.

In white pines as in ribes we are presented with species variations in response to invasion by the pathogen and to its subsequent development. Inherent (genetic) susceptibility, age and vigor of the host, size and configuration of target, length of time that needles are retained all contribute significantly to the problem of host-parasite relationships. On the bases of infection tests and of field observation on natural infection, we recognize significant differences in susceptibility of the native white pines. P. albicaulis, lambertiana, monticola, flexilis, strobus are named in descending order of susceptibility to the rust. P. aristata and balfouriana are definitely lower than the first mentioned group. There is some doubt about the susceptibility of balfouriana; at any rate it is definitely below that of white bark and western white pine.

In rounding off this skeleton outline of the ecology of C. ribicola and the importance of this work to the effective conduct of large scale control, we can clearly see that research as usual both provides answers and poses new questions. The story of blister rust disease and blister rust control is supported by an imposing shelf of publications, and yet there are still wide gaps in our understanding of rust behavior under natural conditions. This may be a sobering thought when we look at many other diseases of economic importance for which control methods are urgently needed. Perhaps we can conclude appropriately with a comment of Lincoln's that "The dogmas of the quiet past are inadequate to the stormy present."

STEM DISEASE ECOLOGY - RUSTS PANEL

Summary of Discussion

W. W. Wagener

In the discussion, it was brought out that the prospects for expanding the application of microclimatic studies on blister rust through the use of Weather Bureau records were not promising because of the location of most Weather Bureau stations in places not representative for forest areas in which we are concerned with rust problems; also that there was a need for bridging the gap in some manner between the results of microclimatic studies and the general weather pictures as provided by usual Weather Bureau records. Data obtained on a microclimatic basis should be possible of extension later macroclimatically and to diseases other than white pine blister rust. In considering climatic and topographic influences on infection of pines, it must be remembered that only certain portions of moist periods may be critical, such as rainless calms at night when drift of sporidia may take place without their loss by being carried out of the air or off of foliage on which they may have lodged by water droplets. For better data on time and extent of sporidial dissemination, the possibilities of sampling by means of spore traps was pointed out. The importance of keeping in mind the ecology of the host as well as the rust organism was emphasized.

Melampsorella rust, with two species represented, was reported as a real problem in parts of Colorado on spruce and fir. The species on spruce is different than the one on fir but both have chickweeds as alternate hosts. The same situation was reported for Wyoming but with the rust on spruce much more common than that on fir. Chickweed was said to be abundant in association with affected stands in both states. In Colorado the rust is responsible for many broken tops in spruce and the broken stubs left on the spruces are said by entomologists to form attractive material for attack by the spruce beetle.

ECOLOGY OF TREE ROOTS AND ROOT DISEASE PROBLEMS

by R. G. McMinn

Ecology is the study of the reciprocal relation between plants and their environment. The ecological requirements and limitations of the root system, as well as those of disease organisms must play a considerable part in the incidence and severity of root disease occurrence. Some of the factors which modify the basic morphongenetic pattern of root development in a tree species are its crown class and vigour; soil depth, effective volume and texture; soil fertility; soil moisture levels and their periodic fluctuations; soil seration and soil temperature. All these factors have a bearing on root development and vitality, on that of the disease organism and on the balance between them. Thus it has been observed that suppressed or weakened trees were more susceptible to root rots by such organisms as *Armillaria mellea* (1) and spruce which had been subjected to budworm defoliation was found to have a high incidence of rot (11). Day propounds the theory that weakening and greater liability to root disease occurs when trees grow in a soil depth or volume inadequate to support them beyond a certain size (4). In an investigation of stand openings in a spruce forest, Van Groenewoud found them to coincide with areas of shallow soil (5). Soil horizons impenetrable to roots may also be impenetrable to water causing a high water table at certain seasons, with the resulting root damage often being attributed to lack of adequate aeration (6). Soil fertility, of course, plays a large part in controlling the vigour of tree growth. Deficiences, often of microelements, are well known in orchard trees and they presumably also occur in forest stands. Soil moisture is often a critical factor, with deficiencies causing physiological distress and reduced growth and presumably because of root mortality, increase in the number of infection courts available to root rots. Periodic excess may cause root mortality through lack of aeration as noted above or through moist conditions promoting the spread of such organisms as the various *Phytophthoras* responsible for root rots in a variety of trees (3). Soil temperatures under forest stands rarely, if ever, reach lethal values. However, increased temperatures may have a deleterious effect, possibly through a disturbance of the normal balance between roots and soil or root inhabiting organisms (10). The importance of environmental or ecological factors, therefore, cannot be overlooked in an investigation of root diseases.

The writer has been concerned with an investigation of the root system of western white pine and its relation to pole blight (8, 9). These studies were designed to investigate individual healthy trees and trees in various stages of decline. Considerable information on individual trees has been obtained by manual excavation, for example by Laitskari in Finland (7), but this method is most time-consuming when any number of the very lengthy pine laterals must be followed out. Manual excavation is better adapted for spot sampling, a fairly rapid method of studying roots on a stand basis (2), and for transect sampling to study soil profine-root depth relations (13). Hydraulic excavation was chosen as a more suitable method for the examination of more or less entire root systems. It was also chosen because samples for study of the absorbing elements could be collected at the same time. Twenty healthy trees and fifteen in various stages of decline have been excavated.

A strong correlation between crown size and vigour, and root length was found. For example, with a sixty year old tree, 16.6" dbh and 75 ft. high, the total length of all roots greater than 1 cm. in diameter was 195 meters, while an adjacent fifty year old tree, 6.3" dbh and 53 ft. high had only 38 meters above the same diameter limit. Differences in the length of small lateral roots (5-10 mm.) were equally impressive (more than 265 meters for the larger tree and 51 meters for the smaller). In the vertical system the larger tree had 36 sinker roots (greater than 5 mm. in diameter) within a radius of one meter from the root collar while the smaller tree had only 8.

The influence of soil depth on the length of vertical roots was evident. Where the profile was shallow verticals extended only as far as the impenetrable layer, which in some locations was less than one meter from the surface. In a deep sandy soil some of the main verticals were traced to a depth of more than four meters. Above the hardpan layers verticals with stubby callused ends were fairly common, indicating some die back of the tips in this periodically waterlogged zone.

The lateral systems of larger trees were characterized by very long roots with little branching. In sandy soils the fine roots bearing the absorbing rootlets were largely confined to roots less than one centimeter in diameter. Branching to form the 1 cm. size class occurred mostly towards the ends of the main laterals. In heavier soils some fine roots were carried by larger roots (up to 5 cm. in diameter) but the general pattern of a sparsely branched system, with the smaller branches at some distance from the root collar (3 to 4 meters or more in la ger trees) prevailed.

Root grafting among laterals was uncommon. In verticals it was confined to those within the root collar region, where it was very common in trees with a shallow system, but less common where the system was not restricted.

Such a diffuse lateral system, while capable of tapping soil over a large area, would appear to suffer some disadvantages. The small and fine roots (which carried the mycorrhizal rootlets) were relatively infrequent, long and sparsely branched. When such roots were girdled by root rot the entire distal portion and all its rootlets were lost to the tree. In a more profusely branched, denser system, such as that of hemlock, the loss of a fine root branch might represent the loss of a smaller proportion of the absorbing system. Similarly the girdling of a main lateral in pine usually entails the loss of all the roots distal to the girdle, but in hemlock which has more frequent grafts, the distal part of the root might have an alternative path to the root collar through a graft.

All the trees examined, both healthy and pole blight, had suffered some loss of structural roots by girdling. *Armillaria* fans were usually associated with these areas. The amount of dieback varied considerably, with some trees having many of their main laterals girdled off within a short distance of the root collar. However, the girdling or dying back of the main roots seemed somewhat incidental to the cause of pole blight for some dead trees were found with few roots showing evidence of *Armillaria*, while others appeared to have lost most of their structural system before death. This difference may be partly a function of the length of time the tree took to die. If death was rapid, there would be little time for *Armillaria* to attack weakened roots, while if decline had occurred over a longer period, more roots might be destroyed by this fungus.

In several of the pole blight affected trees examined a considerable length of the structural roots was moribund or dead without resinosis or evidence of fungal attack prior to death. The roots of trees in the later stages of decline were mostly devoid of fine branches or these branches had died back to mere stubs. Pole blight affected trees also appeared to have relatively few active mycorrhiza, although they were common on adjacent healthy trees. This lack was presumably in part a reflection of low crown vigour. During the final stages of decline roots and rootlets appeared to lose vigour and may have died from internal causes rather than external infection.

Such a sparse and widespread system as that of white pine, with the absorbing elements at oonsiderable distances (up to 10 meters or more) from the stem could conceivably render the tree at a disadvantage in periods of moisture stress, particularly if xylem production had been poor for several years previously restricting the volume of active conducting elements. Smaller trees with less extensive root systems and less exposed crowns would presumably be at a smaller disadvantage. This difference could be one of the factors accounting for the observation that there has been a greater incidence of pole blight in dominant than suppressed trees.

It was evident from this study of the morphology of pine roots that pole blight is not the result of a root rot causing a loss of structural roots, as in the case of *Poria weirii*. The decline appears more systemic in nature, accompanied by a reduction in mycorrhizal vigour. An investigation of the physiology of pine and other species of pine stands appears necessary to account for this decline in vigour. The white pine region has undergone a period of drier and warmer summers than the long term average (12). Such a climatic cycle might affect white pine more severely than other species or recovery from any ill-effects may be less rapid.

Experiments have been initiated to determine whether there is any difference in response of pine to adverse temperature and moisture conditions or difference in speed of recovery when such conditions are alleviated. In the field, drought shelters have been constructed to cover the root systems of pine, Douglas fir and hemlock trees. No foliage differences were apparent at the end of the first summer. A pilot soil heating experiment showed a differential response between pine rootlets and pine mycorrhiza. Active root tips were found close to the soil heating cable, where the temperature rise averaged 10°C above normal over an 8 week period, while most mycorrhizal rootlets were dead. This difference may also have been a response to drought for the soil in the vicinity of the cable dried out appreciably. Further field experiments are planned to amplify these results. Greenhouse experiments using Wisconsin tanks are being initiated.

This investigation into the root system of white pine serves to show that environmental factors influence root development. Further physiological and ecological studies may also show the climatic factor to be of prime importance as a cause of pole blight.

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SITE AND MOISTURE RELATIONS OF BUTT-DECAYING FUNGI IN SUBALPINE SPRUCE IN ALBERTA

by D.E. Etheridge

As the title implies I shall discuss the role of site in relation to butt-decays in subalpine spruce, but more specifically, and as a result of a continuation of my ecological studies of decay which include some recently completed laboratory experiments, I shall present some evidence which suggests that site moisture conditions and the moisture content of the heartwood of trees are important factors affecting the disease status of a stand. These factors, it will be shown, vary considerably in trees on different sites which can be recognized in the forest by their characteristic vegetation.

1952 STUDIES

These studies have developed from investigations of decay in subalpine spruce carried out on the east slope of the Rocky Mountains during 1952 and 1953. The 1952 work was primarily a cull study, but data was also collected on the ground vegetation and associated site factors for the purpose of describing the stands. When the site data were analysed, however, two distinct plant associations were recognized which were consistently associated with dry or moist sites. Accordingly, on the basis of certain plant indicators, the plots were separated into dry and moist site classes and the incidence and amount of decay were determined for each class. This analysis showed that both the average gross volumes and the incidence and volume of decay were much greater in trees on the moist sites than on the dry sites. There was no evidence that more destructive species of fungi occurred on the moist sites than on the dry sites which suggested that the rate of infection in the stands was largely a function of conditions of growth and the characteristics of the trees.

1953 STUDIES

To elaborate on the 1952 observations, a systematic survey of the east slope region was made in 1953 to examine more critically site factors in relation to root- and butt-infections of subalpine spruce. Because of the earlier success in utilizing plant indicators to delineate infection classes a major objective of this study was to establish a system for classifying the disease status of a site based on characteristics of the vegetation. In other words, by making a comprehensive survey and analysis of the vegetation occurring in different spruce stands it was hoped to develop a system of indicator plants which might serve to distinguish between stands having low, moderate or excessive numbers of infected trees. On the basis of this classification it was then intended to examine the association of factors of the topography and soil to discover if other criteria existed which demonstrated the ecological distinctiveness of the site.

The study was based on 53 sample plots established within the spruce type in uncut stands representing a variety of site and stand conditions. Records were made on the elevation, aspect, slope, and ground cover composition, and samples were taken from the "B" horizon of the soil for laboratory determinations of total nitrogin, pH, and texture. The depth of the A_0 horizon i.e., the humus without the litter, was measured on each plot. Basal infections were determined from samples obtained with an increment borer from the base of the trees; trees with a diameter greater than nine inches were bored at right angles to detect possible eccentricities in the rot pattern. Infection ratings for each plot were determined by calculating the ratio of infected spruce trees to the total number of living spruce trees occurring on each of the plots. Usually, it was possible to examine at least 10 spruce trees on each plot. For the vegetation analysis, the plot data were first separated into distinctive geographic regions and then arranged into two groups of plots representing low (0 - 20%) and excessive (40% or more) numbers of basally infected trees. The presence of specific indicator plants in each of these arbitrary units was determined by using Braun-Blanquet's method for estimating the significance of plant indicators in plant associations. For this purpose, each unit was regarded as a distinct plant association. Depending upon the relative occurrence of low infestion and high infection indicator plants the plots were then separated into three site types each of which represented a natural unit of vegetation presumably having similar environmental conditions.

To test the validity of this system for delineating pathological site, the individual trees were seperated according to site, arranged into age classes, and the incidence of infected trees was calculated for each class. This analysis showed that the perccentage of infected trees increased with increasing age of the trees at different rates for the three sites. The average infection values obtained for the three site classes were 12.1%, 22.2% and 35.1%. This appraisal led to the conclusion that the disease status of the site types could be designated I, II, III, thus providing site indexes for stands having low, moderate, and high numbers of basally infected trees respectively. It is noteworthy that at the advanced age of 270 years, only 15% of the spruce trees that were examined on the class I sites were infected, while all of the trees of this age on the class III sites possessed some evidence of basal infection. The sites were also characterized by different age structures; the older age classes viz., those in excess of 150 years, contained 57% of the trees on the class I sites, 44% on the class 11 site, and only 37% on the class III sites. I feel that this relationship independently serves to emphasize the much slower rate of deterioration which occurs in stands on site class 1.

In view of the conflicting opinions held by forest pathologists regarding the connection between rate of growth and decay resistance in trees, it is of some interest to outline a relationship that was found in the data between the average width of the annual rings and the three pathological site classes in overstorey and understorey trees. I refer now to Table 1.

These observations indicate the existence of a definite link between the rate of diameter growth and susceptibility to infection in sub-alpine spruce. There is evidence of a consistent increase in the chances of infection with an increasing rate of diameter growth. Using height as a criteria of growth, a similar but less pronounced trend was obtained but this might be due to the fact that average height values unlike the average diameter values were not based on all the trees occurring on the plots but on one or two dominants.

Attention was next directed to the possibility of discovering if other criteria exist which demonstrate the ecological distinctiveness of the pathological sites. The positive or negative association of any particular factor, e.g., high or low nitrogen content of the soil, or, high or low elevation, with a particular site, was appraised by first separating the plot data into two groups each group representing one of the two opposing effects to be tested, and then arranging the data in contingency tables under the appropriate site class designated for the plot. If a relationship was absent, the observed frequency of the plots falling into a particular site class should approximate the calculated expectations, and the resulting chi square value would be small. For example, I have prepared a table (Table II) to show how the frequencies for the plots from high and low elevations are distributed among the three site classes. Initially, an arbitrary altitude value defining the class limits was employed and the value which gave the best contingency chi square was taken to represent the critical value for the maximum environmental effect of the factor on infection. In this case, an elevation of 4400 feet above sea level gave the best chi square value being significant at the .01 level of probability. The results of analysing other factors employing this method are given in Table III. The importance of such physiographic features of site as elevation, slope, and aspect can be seen from this data. Thus, stands of spruce which are located on a west, southwest, or south slope having a gradient in excess of 15.5 per cent at altitudes below 4400 feet might be expected to support more infected trees than stands which do not have these features. There is also evidence that more infected trees occurred on acid soils, i.e., below pH6 than on neutral or alkaline soils. Most severely infected stands were associated with soils characterized by a relatively thin humus layer.

The conclusions that may be drawn from these observations may be briefly stated as follows:

(I) The incidence of basal infections in subalpine spruce in Alberta is dependent on conditions of the site and the site types so derived are expressed by their floristic structure.

(2) Differences in the vegetation occurring between the low infection and high infection sites appear to reflect differences in the moisture conditions since indicator plants for the low infection sites include such xerophytic plants commonly associated with dry sites in Alberta as Juniperus canadensis, Shepherdia canadensis, Arctostaphylos uva-ursi Fragaria glauca, and Pinus contorta. Thus, ecologically, the class I sites with a low incidence of disease might be described as dry, and the class III sites where hydrophytic plants dominated as moist.

(3) A slow rate of growth appears to be associated with a high disease resistance in subalpine spruce.

(4) Severely diseased stands were commonly situated at the lower elevations on pronounced slopes with a south or west exposure which has led to the conclusion that the warmer sites are more susceptible to basal infections.

The two most important ecological factors emerging from these studies which were most closely linked with the disease status of the stands appeared to be the moisture and temperature conditions of the site. The characteristic of the trees which was most closely related to decay resistance appeared to be a slow rate of growth expressed by relatively narrow annual rings. Therefore, I would like to use the remainder of the time at my disposal to describe some results of my recent laboratory experiments dealing with the nature of decay resistance in slow-grown and fast-grown spruce wood, and to touch briefly on the ecological significance of moisture and temperature on the activity of heartrot fungi which follows from these experiments.

(1) I found that the heartwood of healthy fast-growing trees on a wet site contained significantly more water than slow-growing trees on a dry site.

(2) In the living trees sampled, an increase in the moisture content of 3 per cent of saturation resulted in an increase in the incidence of non-decay producing fungi from 0 to 13.3 per cent.

(3) In test-blocks of wood from the same trees an increase in the moisture content of 3.4 per cent resulted in a statistically significant difference in the rate of decay by Coniophora puteana, a native butt-rotting fungus.

(4) The effect on decay of wood properties associated with the different rates of growth in these trees was negligible.

(5) The threshold moisture content for infection in the trees was 8.5 per cent of saturation, and for decay in the test-blocks was between 5 and 10 per cent.

(6) The moisture content of the butt region of the trees was appreciably higher than the moisture content at 20 feet from the ground. There is also some evidence from a Russian source that the stem temperature of Scots pine is lower at the ground level than at D.B.H.

(7) In the laboratory tests, the optimum moisture content for maximum development in wood was found to be higher for butt-totting fungi (4 species) than for trunk-rotting fungi (3species) that occur on spruce. The optimum and maximum temperature for growth on agar was about 5°C lower for the butt-rotting fungi. Thus both the moisture and temperature conditions of the habitat seem to be of considerable ecological importance in determining the relative dominance of these fungi in certain parts of the trees.

In summary, my studies emphasize the importance of utilizing an ecological basis for forest disease investigations. Employing such a system I have gone a little further and have demonstrated the ecological significance of the moisture conditions of the habitat on the activity of fungi causing heartrot in subalpine spruce. Unfortunately, time does not permit my dealing with these conclusions in greater detail, however, a report on the 1952 work has been published and separates are in the process of being distributed. Memeographed reports on the 1953 studies and the recent laboratory studies will be available for distribution this winter.

TABLE I

AVERAGE RING- WIDTH (IN INCHES) OF OVERSTOREY AND UNDERSTOREY SUBALPINE SPRUCE TREES ARRANGED ACCORDING TO SITE CLASSES

	Site Class I (low infection)	Site Class II (moderate infection)	Site Class III (high infection)
Overstorey Trees..	0.039	0.047	0.053
Understorey Trees..	0.027	0.029	0.032
	Dry ←		→ Moist

TABLE II

DISTRIBUTION OF PLOTS REPRESENTING HIGH AND LOW ELEVATIONS AMONG THE THREE PATHOLOGICAL SITE CLASSES

Altitude feet (above sea level)	Frequencies					
	Site I		Site II		Site III	
	Obs.	Cal.	Obs.	Cal.	Obs.	Cal.
Below 4400	0	5.4	7	4.2	8	5.4
Above 4400	19	13.6	8	10.8	11	13.6
Totals	19	19	15	15	19	19

Total chi square = 11.886 P= .01

TABLE III

EFFECT OF SITE FACTORS ON THE INCIDENCE OF BASAL INFECTIONS IN SUBALPINE SPRUCE

Site factor having a positive influence on the rate of infection	Critical level	Sample basis	Contingency chi square	Probability
Aspect	South-west, West, W. SW. S.	23	7.371)	<.05
"		52	6.475)	>.02
Altitude	Below 4400'	53	11,886	.01
Slope	>14.5 per cent	53	14.173	.001
Soil texture	Light vs heavy	53	0.132	Not Sig.
Depth of humus (A_0)	<1.75	47	6.157	<.05 >.02
Soil nitrogen (total)	Over range 0.100 to 0.140%	53	0.043 to 2.240	Not.Sig.
Soil pH	<5.95	53	6.420	<.05 >.02
Degree of windfall	Light vs. heavy	42	1.990	Not.Sig.
Site Indexes	Incidence of disease			
1 (dry)	0 - 20%	53	22.839	.001
2 (intermediate)	21 - 40%	53	"	"
3 (moist)	>40	53	"	"

DEGREE OF FREEDOM = 2, except for the site index item which is 4

Note: Soil samples were taken from the B horizon

SOME POSSIBLE RELATIONSHIPS IN THE ECOLOGY OF PORIA WEIRII

By T. W. Childs

If you are thirsting for facts about Poria weirii, you've come to the wrong place, at least for the next 12 minutes. We know or suspect a number of things about the ecology of other root rots--for example, the effect of soil moisture fluctuations, and of basic ions in the soil, on spread of Armillaria--but thus far we have accumulated little information of this kind in our work on laminated root rot. Accordingly, I must make a virtue of necessity and let Hypothesis soar on the wings of Imagination, far above the lethal birdshot of Reality. Any reference to conditions actually existing in the woods is intentional but should not be taken too seriously.

Direct effects of the physical environment on Poria weirii seem relatively simple. For example, spread and damage are slower on cold sites than on warm ones, and it is reasonable to assume that this is merely an instance of the well-known effect of temperature on growth rate of fungi. P. weirii, however, leads a sheltered life. Most of the action of the physical environment on it must be exerted indirectly, through its host and probably also through other elements of its biological environment. Such indirect relationships can be exceedingly complex.

As an example of the chains of causes and results that must be untangled by ecological research, take the effect of stand density on damage by this disease. The first step is to look for a correlation between the two variables. This requires analysis of spatial relationships between individuals that differ in species, size, and degree of dominance, and that may be living, killed directly by any one of a number of causes, or killed by a complex of causes of which a single one may or may not be primary. The analysis involves not only current relationships but also relationships during earlier stages in the growth of the stand--stages whose remains are fragmentary at best. It requires distinction between mortality that reduces yield, and mortality, from whatever cause, that promotes development of the stand along desirable lines.

Patterns of distribution of individuals in wild populations have been studied by several ecologists, and some statistical theory is available. Mathematical tools, however, must be used with caution, since the biological bases of the distribution patterns are obscure. For instance, "randomness" is supposedly a characteristic of large-tree distribution, as opposed to "contagion" in seedling stands. But "randomness" in mature stands is largely a result of two non-random processes: a higher survival of seedlings in the more favorable niches, and a higher mortality in the same niches as the crowded trees become larger. The relative effectiveness of these two processes, and consequently the applicability of random-population concepts, varies with the species and with the environment. It must be remembered, too, that the disease itself is a non-random element of considerable importance in its host's environment.

Such complications are illustrative of those to be expected in the first step of the project, but they are not insuperable obstacles. We may therefore assume that after a lot of work in wild stands we find a positive, significant, and fairly large correlation between density in the small-pole stage and subsequent damage by Poria weirii.

We have made only a beginning. The correlation does not prove that density contributes to damage. Consequently, it does not by itself entitle us to conclude that damage can be reduced through artificial alteration of density. From other studies we can add a few pertinent facts. Spread of the disease within foci is known to be vegetative. The work of Buckland, Molnar, and Wallis leaves little room for doubt that most if not all such spread is through root contacts. It has been observed that Poria weirii is often unable to invade wood decayed by other fungi, and this suggests that spread may be principally through living roots. Taken altogether, the evidence supports the hypothesis that damage tends to be greater in denser stands because contacts between living roots are more numerous there.

But the correlation can be adequately explained by other hypotheses. For instance, most root-rot foci become occupied by deciduous shrubs or hemlock reproduction. There are grounds for belief that an interval of "brush-fallow" increases the capacity of forest soils to support coniferous trees. Hemlock reproduction, by densely shading the duff and thereby reducing the intensity of the burn that terminates the rotation, may also render the site more favorable for subsequent establishment and survival of Douglas-fir. Density will then be highest where infection was most severe during the preceding rotation; that is, where the greatest abundance of inoculum will engender the heaviest damage during the current rotation. According to this hypothesis, density and damage are not cause and effect, but are simply two effects of the same cause. It should be noted that nothing in this latter hypothesis precludes the possibility that damage by Poria weirii, like damage by Armillaria, may even be increased rather than decreased by thinning.

As another example of ecological complications, take the effect of forest succession on incidence of infection. The disease is less common, and usually much less common, in mixed than in pure Douglas-fir stands, and is very unevenly distributed in pure stands. This situation can be attributed to increase in the amount of inoculum as pure Douglas-fir stands occur in uninterrupted sequence for several rotations, and to decrease of inoculum as killed root systems decay and disappear during interruptions in this sequence. The hypothesis here might be that spread of the fungus is impeded by scarcity of root contacts between susceptible hosts in mixed stands, and especially in climax stands, and that exhaustion of inoculum eventually permits again the growth of a relatively healthy stand of pure Douglas-fir.

This "sick soil" hypothesis conforms fairly well to what we know about the disease. It may, perhaps, be considered sufficient basis for recommending mixture of other conifers with Douglas-fir as a control measure on sites where damage is severe. Here again, however, alternative conclusions are possible.

For instance, gradual invasion of Douglas-fir sites by climax species may be accompanied by physical changes in the soil and multiplication of soil micro-organisms that hinder spread of the disease across non-grafted root contacts. This change in root environment may not occur, or may be exceedingly slow, when the forest type is altered rapidly by drastic management methods. Another alternative is that relative freedom of climax species from the disease is attributable to root patterns formed during early periods of suppression, such as occur in most natural stands, and that these prophylactic patterns may not be formed in managed stands where juvenile growth is faster. Neither of these hypotheses supports the conclusion that control may be obtained through artificial mixture of other species with Douglas-fir.

The foregoing hypotheses are perhaps a little far-fetched, but they exemplify a difficulty that pervades research in the ecology of disease. Our conclusions are only the most probable among many possibilities. Although their validity will ultimately be determined through experimental or practical application, this process will usually be slow and may be exceedingly costly when we back the wrong hypotheses.

As our research deals with increasingly complex relationships, and as intensification of forest practices increases the need for immediate and reliable results of research, we are necessarily devoting more and more of our effort to collection and analysis of large quantities of observational data. This method is indeed a useful tool, but there is danger that its potency may blind us to its deficiencies.

To illustrate the limitations of analysis by formula, let me digress briefly to a much simpler subject than ecology. It is possible to construct an electronic computer capable of winning chess games from good players, but the best machine that could now be built would lose to an expert. The machine must consider every possible move, and even at the rate of ten thousand operations per second it would require several hours to evaluate all the combinations possible through four moves. The expert uses his experience, strategic talent, and subconscious or "intuitive" understanding of positions, to select those few moves that promise favorable continuations. He can then, within a relatively short time, evaluate these lines of play through at least six and sometimes through as many as sixteen moves.

The old-fashioned ecologist used the chess expert's approach. He carefully observed his universe, focused an experienced and well-stocked mind on the elements of his problem, and arrived surprisingly often at a correct conclusion. Today we can solve problems beyond the capacity of the old-timer, but our modern methods are not an unmixed blessing. Whether by electronic computers or by more primitive processes, they can only supplement--they can never supplant--the expert's personal contribution. Moreover, the very process of accumulating great masses of data is adverse to keen observation and unhurried reflection on the phenomena with which we are concerned.

Herein lies the moral of my discourse. Man's intellect has powers that transcend those of its mathematical servants, and we cannot afford to starve it of raw materials through concentration on routine processes. Even though we shall always need more data than we can get, let us take time, frequently and deliberately, to look at the forest around us and to think about the organisms, processes, and relationships of which it is the sum. I don't mean that we should abandon facts for a mystical rapprochement with the subjects of our research. I do mean that the synthetic or integrating approach to ecological problems is at least as productive as the analytic approach, and that that most marvelous of integrating mechanisms, the human mind, should be supplied with the information necessary for its operation.

STEM DISEASES - DECLINES AND WILTS - Panel

Lake S. Gill, Moderator

Our subject this afternoon is "Stem Diseases: Declines and Wilts". Undoubtedly we each have our individual concepts of the difference between Declines and Wilts, but perhaps this over-simplified distinction will be acceptable:

Wilts are associated with sudden death of the tree or parts of its crown.

Declines imply a lingering slow death of the tree, preceded by a gradual decline of crown vigor.

If these diseases have one characteristic in common, it is perhaps the fact that serious disturbances in the translocation and transpiration processes occur before there is appreciable necrosis of the phloem tissues.

Wilts are most common in hardwoods, two outstanding examples being the Dutch Elm disease and oak wilt. Neither of these diseases are found in the west, although the principal vector of the Dutch Elm disease, the European Elm bark beetle, is common in the Denver, Colorado area where there are extensive plantings of the highly-susceptible American elm. Is the absence of the fungus disease a fortunate accident or is it a case where environment is the limiting factor?

The principal concern over oak wilt is its potential threat to the vast oak forests of the Ozarks. I believe that some recent studies involving the ecology of this disease suggest that the high temperatures prevailing in the Ozarks may discourage the causal fungus from perpetuating itself there.

While we are inclined to ignore the importance of wilts in conifers, I hope some of you will open further discussion on this point. For example, does the *Phytophora* disease of cedar on the west coast fall in this category? Should we regard the bluestain fungi associated with primary bark beetles as wilt-inducing organisms?

It so happens that both of our panel speakers have chosen to discuss declines. There are two good reasons for this. First, they both have broad experience in the field. Second, declines are perhaps more involved with the external environment of trees than any other group of diseases. They are "naturals" for a meeting devoted to the ecology of diseases. Declines in plantations or in managed stands where composition and age distribution have been radically altered are not uncommon manifestations of the changed environment. In more or less natural stands where the artificialities or alterations are not too obvious, the investigators of a decline are apt to be faced with the proposition of disproving the involvement of a highly infectious catastrophic disease before they can get down to a study of the environmental factors contributing to the disease. Having reached that point, the investigators must usually start from scratch because with most forest species their normal responses to environmental factors are imperfectly known. The pathologist, therefore, must often investigate the normal before he can explain the abnormal.

ECOLOGICAL CONSIDERATIONS OF THE POLE BLIGHT DISEASE

By Otis L. Copeland, Jr.

An ecological discussion of pole blight must necessarily be broad so as to include certain interrelationships between the species in question and the environment. Thus this discussion includes autecology and synecology, though the distinction may at times be finely drawn or almost obscure. For this reason, let me remind you of Charles E. Bessey's advice, "Keep your minds in a meristematic condition."

Ecology implies relationships to environment and environment is composed of a number of factors. Among those of primary concern in this discussion are edaphic, climatic, and biotic factors.

Edaphic factors are seated in the soil mass, the medium for tree growth. Some of the more important ones are: soil depth, water relations, aeration, reaction, fertility, and temperature. Many of these are influenced by topography and aspect. Irrespective of the individual factor, all have maximum and minimum intensities and in between lies an optimal point favorable to the best tree growth.

Climatic factors include temperature, humidity, precipitation, wind, and light.

Biotic factors are considered broadly and will encompass not only micro-organisms but associate tree species as well.

Pole blight has been known to exist for the past 27 years. It has been under intensive investigation for about a decade. Its cause and control are still unknown, but like any other complex disease, particularly of long-lived forest trees, years of painstaking research are necessary to explore the multitude of possible causes. We are nearer to the solution of this problem than ever before. If not by the gathering of information through research leading to a determination of the cause, then simply by the passage of time. We prefer to feel the former more appropriately describes the situation.

The question, "Is this really a new disease, or has it been present for centuries?", is often asked. Pole blight is presumably a new disease, at least to this century. Many capable and noted workers ranged the white pine type for a score of years or more prior to the observance of the disease. Had it been present earlier, undoubtedly it would have commanded their attention because of its eye-catching symptoms and the stand devastation in the more advanced stages. The possibility of its being a recurrent problem has been advanced, but we have no information to substantiate this viewpoint.

Let us now consider the ecological factors operative within the white pine type, bearing in mind the disease under consideration.

Western white pine is a sub-climax species and is often referred to as a fire type. Perpetuation is favored by major accidents, particularly fires, thus the stands are relatively even-aged and the degree of purity is largely determined by the intensity of the accident (fire) and the proximity of other species capable of seeding in. Climatically, the white pine type is characterized by a short summer season of scanty precipitation, low humidities, and clear, hot, sunny days. The winters are long with heavy snowfall and low temperatures.

About four months, from May to August, constitute the growing season during which extended drought periods occur frequently. At the Priest River Experimental Forest, located in the northern portion of the white pine type, during a 20-year period (1912-31), out of a possible 92 days in June, July, and August the number of days without measurable precipitation ($<$.01 inch) ranged from 53 to 80. Mean annual precipitation ranges from 28 to nearly 50 inches, but there again is tremendous annual variability.

White pine occurring as a pure stand is almost a rarity. Rather, it is found growing in association with a number of species, notably larch, Douglas-fir, grand fir, western redcedar, western hemlock, and Engelmann spruce. Growth habits, rooting habits, and tolerance differ among these trees. Whether to the detriment of one or the other is unknown, but I shall discuss this in more detail.

Within the white pine type, there are numerous soil organisms--some pathogenic, others non-pathogenic. But to our knowledge at the present, we do not have a fungus that is considered to be an outstanding pathogen. We do know that *Armillaria mellea*, *Fomes annosus*, and others can be "bad actors", but are they involved to a marked degree in pole blight? *Leptographium* has now been relegated to a position of secondary importance.

Now that a small amount of background information has been presented, let's examine more closely the actual problem--its occurrence, distribution, damage, and work to determine its cause.

Damage Appraisal

Distribution surveys show that in the western white pine type in the United States, about 95,000 of the 750,000 acres of pole-size stands are moderately to severely damaged by pole blight. Additionally there are other small areas of light scattered damage whose extent has not been determined. As most of you know, losses due to pole blight are particularly important because the acreage of pole-size stands in the susceptible age class (40 to 100 years) is already considered insufficient to meet foreseeable needs.

Don Graham has completed a damage appraisal survey in 16 stands that have been affected for various periods of time: those affected most recently, those affected for an intermediate period, and those affected for the longest known time. This survey included 724 1/10th-acre plots. Results of this survey can be summarized as follows:

	WWP basal area affected	
	Average	Range
Recently affected	29%	
Intermediate length	45%	35 - 58%
Oldest affected	68%	45 - 81%

These plots contained 14,852 white pine trees with a basal area of 5,482 square feet. The grand average is 57 percent of the total western white pine basal area either affected or dead for all stems of all diameters. Sixty-three percent of both stems and basal area were in diseased and dead trees over 9 inches d.b.h., leaving only 37 percent of stems and basal area in a healthy status.

A reasonable estimate is that affected stands are being reduced in basal area stocking at the rate of perhaps 2 to 5 percent annually. Although ingrowth will reduce this loss somewhat, an appreciable area is being cleared of a desirable species in an important age and size class for an indeterminate period.

Economically, the effects of pole blight losses in a stand are: reduction in stocking, size class, dominance, and composition of the species of highest value.

Ecologically the effects are natural stand conversion, reduction in balanced tolerance of associate species, changed exploitation of soil mantle by root systems, and substitution of low-value tolerant species that further complicate reproduction of desirable intolerant seedlings.

Control Research

Silvicultural treatments--thinning prior to the onset of pole blight and cutting to eradicate diseased stems--have failed to give satisfactory results. In the case of plots thinned about 10 years before the occurrence of pole blight, subsequent pole blight damage is 2.8 times that in comparable unthinned plots or 48 percent vs. 17 percent of basal area affected. Two cutting treatments in a diseased stand, to include (1) the removal of merchantable pole-blighted trees and (2) the removal of all pole-blighted trees, have not aggravated nor moderated pole blight losses.

Causal Agent Research

The essentiality of an atmosphere for life is well known. From an ecologic standpoint there is a direct need of supplying CO_2 for photosynthesis and O_2 for respiration. Animals and chlorophyll-less plants take in O_2 and liberate CO_2 so that a harmonious relationship exists with green plants. The liberation of large quantities of other gases such as SO_2 from industrial sources (air pollution) has been suggested as a possible causal agent. For several years this problem has been investigated. No other species within the diseased areas near the sources of SO_2 exhibited symptoms of air pollution damage, and since pole blight occurred as frequently beyond the sources of SO_2 as it did adjacent thereto, this line of research was terminated.

Grafting trials to determine the possibility of a transmissible virus being the cause of this disease are still in progress. Although I personally do not feel that this presents a highly promising field, nevertheless it is one that must be explored.

Fungal relationships to pole blight have been to a certain extent, circumvented in the current research activities. Early work revealed a host of parasitic and saprophytic organisms, and the status of some is still in question. With due acknowledgment for what has been done, we still need more work along this line. Here an alteration of techniques might help to uncover a missing link.

Soil and root studies constitute an important ecological phase of this problem because the soil represents an environmental influence. Three years have been devoted to a study of soils-roots and pole blight. Don Leaphart and I have carried out this phase of the program. We think we are getting somewhere.

In the first place, the soil is the growth medium for trees. Thus we have the edaphic factor. Roots, root mortality, and root competition, if you will stretch your interpretation, may fall under the biotic factor. The climatic factor soon will be made apparent.

Recently a review of the past 3 years work was completed. I shall enumerate some of the major points that have emerged from our work. Root deterioration is pronounced both in diseased stands and in healthy portions of diseased stands and tends to increase progressively with an intensification of pole blight. Since normal growth depends upon normal functioning of the root system, it seems logical to arrange the sequences of disease development in this order: root system deterioration, radial growth reduction, appearance and intensification of crown symptoms, and eventual death of the affected tree. Rootlet density decreases and rootlet mortality increases as affected basal area increases, showing an intimate relationship between the condition of both the root system and the stand. With an increase in effective soil depth and available water storage capacity of soils providing a more favorable site, there is a decline in rootlet mortality, an increase in rootlet density, and a decrease in pole blight. Apparently, from the soils standpoint, we are dealing with two rather distinct populations: the first, consisting of good soils with an available water storage capacity in excess of 6 inches in the top 3 feet of the soil mantle that support healthy stands; and the second, consisting of shallow, rocky soils usually occurring on steep slopes or hardpan soils of considerably lower moisture storage capacity and commonly supporting severely diseased stands. The subnormal root system of stands occupying the latter category of soils is very marked--only about one-third the number of live rootlets as in the good soils.

Distribution of feeding rootlets is important. Of the rootlets less than 1.1 mm. in diameter encountered in the sampling program, 59.2 percent were in the first, 18.0 percent in the second, and 22.8 percent in the third foot of soil. Rootlet mortality in the upper 3 feet of soil is about 2½ times greater in diseased stands in hardpan soils and about 3 times greater in rocky soils than in healthy stands on good soils. Root abundance in the 2- to 3-foot depth in healthy stands was approximately twice as great as it was in diseased stands.

During the 1952-1955 root samplings, several plots were resampled annually. In some years mortality was only one-fourth that in other years, and this variation could not be attributed to any factor other than moisture availability. Using annual weather records of stations apparently similar in climatic variation to those of the root study areas, a regression analysis showed that rootlet mortality in all plots studied during the 4 years decreased significantly as summer precipitation increased. Where mortality for all plots ranged from 10 to 26 percent for the 1952-53 period, it ranged only from 2 to 15 percent for the 1954-55 period.

Now it seems appropriate to turn again to the ecological aspects of this disease, to present, if you please, our construction of a working hypothesis as to its possible cause.

Aside from its influence in favoring the establishment of a particular plant in a particular region, the period of the year when moisture is suboptimal has a direct effect upon its growth. If a dry season is a characteristic climatic feature, irrespective of its severity, native vegetation, through its adaptation, ordinarily shows no ill effects. But occasionally rainfall falls so far below the normal amount to cause adverse effects on plants. Such an event is referred to as drought. The reaction of the vegetation may vary from slight reductions in size, vigor, and yield, to an outright killing of the plants.

Moisture loss from 6 feet of soil supporting only a fair stocking of white pine ranges from 5 to 8 inches for a 3-month period of July-September. The effectiveness of summer precipitation in recharging soils apparently can be discounted, because of the interception during the normal low intensities. (Under a closed canopy, a 0.40-inch rainfall fails to moisten the mineral soil.) It becomes necessary to rely upon water stored during the spring thaw to carry the stand throughout the growing season. As you have seen from an earlier chart, many of these soils have storage capacities inadequate to meet this demand. Thus the soil moisture level is soon reduced to the permanent wilting point--the moisture constant of greatest ecologic importance. Water held between field capacity and the wilting point (ecologically termed growth water or readily available water) contributes to growth and other physiological functions of plants. From an ecologic standpoint, a soil deficient in growth water is a "dry" soil regardless of its moisture percentage.

Certain species of plants have been shown capable of resisting permanent wilting until the moisture content of the soil is reduced to a point lower than with other species. Many plants with firm-textured leaves or needles may never wilt, although a physiological crisis develops in them just as much so as those exhibiting pronounced wilting. Soil moisture samplings have shown clearly that the available water becomes completely depleted in some diseased stands during the summer growing period. At this point we cannot fail to wonder if some of the associate species might be more aggressive competitors for the limited supplies--this to the detriment of white pine. Leaphart has just completed an intensive sampling of the roots in one acre. The stand is composed predominantly of white pine with a liberal admixture of other species. Comparing the length of fine rootlets ($<$ 1.1 mm.) to the length of small roots (1.1 to 5.0 mm.), the ratio is less than 1 for white pine and Douglas-fir, greater than 2.5 for Engelmann spruce and grand fir.

Reviewing precipitation records at stations within the white pine type, we find tremendous variation from year to year. For example: high precipitation in 1916, very low in 1917, low in 1918, normal annual and very low summer 1919, and low annual and high summer in 1922. From 1928 through 1931, total precipitation was markedly below normal. Since then, variations have occurred but we are now experiencing a definite upward trend. To further our thinking, we have attached considerable significance to the 1928-31 dry period and speculate that prolonged moisture stress may have effected an irreversible physiological disturbance that paved the way for the decline of these stands. I do not believe this is all that is involved. Under conditions of stress, a reduced level of vigor invites fungi and insect attacks. Now to find the fungus, if there is one. Armillaria mellea may enter the picture. It is prevalent throughout the timber type. Boyce regards it as a likely active pathogen following natural or accidental catastrophes--drought being of highest order. A similar view is shared by Rawlings of New Zealand. Unfortunately, Armillaria does not lend itself well to experimental inoculations. This is a handicap--but we cannot stop at this point. Means must be explored to find suitable techniques to assess its importance. Other fungi must also be sought.

Thus at this point, pole blight remains surrounded by complexities involving climatic, edaphic, and biotic relationships. From an immediate standpoint, it complicates the solution of the problem--the determination of the causal agent and appropriate control measures. From a long-range standpoint, this disease and others of a somewhat similar nature emphasize the absolute necessity of a coordinated-teamwork approach. No longer can we remain satisfied with picking at a problem here and there, hoping to find the answer. To further disease research, it is my firm belief that eventually we must organize a group of personnel to study solely the influence of environmental factors--soil, water, climate, etc.--in relation to diseases. This in reality is a study of ecology.

THE EMPLOYMENT OF HABITAT TYPES AS AN AID TO STUDIES OF STEM DECAYS[1]

by

G. P. Thomas[2]

My contribution to our panel discussion of the ecology of stem decays hinges on the assumption that we are concerned with the behaviour of stem decay fungi as they respond to specific environments. Basic to any study of stem decay is the fact that most investigations demonstrate that a limited number of fungi are associated with the bulk of decay. When this is true, as it usually seems to be, the feasibility of directing our attention to a limited number of fungi in the course of investigating a stem decay problem is fairly clearly indicated. An investigation of stem decay as I see it should, therefore, concentrate its attention very quickly on the few fungi which seem to be all-important and should not concern itself very much with the less important fungi. If this attitude is adopted it should be possible at an early stage of any investigation to turn our attention to the biological aspects of the few fungi that are worthy of detailed examination.

There is no doubt in my mind that investigation of the biological aspects of individual fungi will lead us quickly and surely to the solution of stem decay problems and, ultimately, to the necessary understanding of the role of such fungi in forestry. It is understandable, then, that serious thought should be given to the employment of methodologies that are compatible with the type of investigation we have in mind. That part of methodology with which I wish to concern myself today is method of sampling. More particularly, I would like to comment on the kind of sample unit that I feel is suited to investigations involving the activities of a limited number of fungi.

Almost without exception the fungi with which we are concerned are of native origin or are at least sufficiently well established as to exist under a range of natural conditions. The different conditions under which a fungus may exist include those of host in terms of species, age class, vigour condition, and crown class position. Other conditions of fungous existence are those of geographic location, topography, elevation, and

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climate. In short, a fungus exists under a multitude of conditions or influences, each of which is difficult to study separately in the field and equally difficult to simulate in the laboratory. The reason for these difficulties of course is that influences do not act on a fungus separately but are modified in their actions and effects by other influences. Thus, you have a fungus existing in a series of environments which in themselves are the resultant of the interaction of many and augmenting factors. When we come to think of sampling environments, as representing the conditions under which a fungus exists, how do we go about it?

Without knowing much about a fungus, other than its identity and its apparent importance as the cause of decay, we have at the outset of an investigation very little to guide us in deciding upon the kind of sample unit best suited to our purpose, let alone the number and size of sample units needed. Under these circumstances there is opportunity and justification to sample blindly at first, hoping that a more discrete type of sampling will materialize as the investigation proceeds. While it is just about impossible to avoid blind sampling at some stage of an investigation, usually an initial stage, I suggest that this initial period of probing be limited to as brief a time as possible. Under no circumstances should an investigation be pursued very far without benefit of a proper basis for sampling. What, then, should we look for in a proper basis for sampling?

In discussing what should constitute a proper basis for sampling we might review our concept of a sample unit. I prefer to think of a sample unit as a category within which to file observations. Consequently, sampling to me involves the filing of observations into categories, each category being homogeneous in itself and distinct from others. When applied to a situation that embodies a range of conditions, hence a range of environments, a sample unit of these conditions does, in fact, constitute a unit of environment. It appears, then, that recognition of specific environments might serve as a basis for studying fungi that exist under a range of environments, viz., stem decay fungi. Unit areas of specific environments could, therefore, constitute the desired sample units.

This line of thought leads to the question of what is a specific environment and how can its existence be detected. Furthermore, how can unit areas over which a specific environment persists be delimited and thereby used as sample units? I would say that a specific environment can be considered as the resultant condition created by the existence of an ecosystem, the ecosystem itself being comprised of a stable balance of soil, topography, climate, and vegetation. An ecosystem is, therefore, somewhat intangible yet its component parts are real. Ecosystems can be recognized most readily by their characteristic vegetative communities, either of the order of plant unions or plant associations. Of the two, the plant association has become the most widely accepted vegetative unit of biogeographic classifications and represents a distinctive combination of plant unions.

Thus, ecosystems and, therefore, specific environments can be recognized in nature according to the occurrence of their characteristic vegetations, viz., plant associations. The collective area which a particular association occupies could be termed a habitat type.

All occurrences of a particular habitat type represent a high degree of biotic similarity despite the fact that there may be considerable variation in one or other component of the ecosystem designated by the habitat type. This feature of biotic similarity in all stands of the same habitat type justifies, in my opinion, the acceptance of habitat types as the desired sample units for investigating stem decay fungi. A word of caution could be interjected at this point, to the effect that biogeographic classification must logically be based on climax or self-regenerating plant communities and not on seral or temporary communities. The reason for this stems from the fact that vegetation is the least durable component of an ecosystem and normally has several temporary stages of development toward its ultimate stable or self-perpetuating condition. Consequently, when stem decay requires study in different host species and in different age groups of these species the first necessary operation should be a biogeographic classification of mature stands in the region of study. Only by such means can seral communities be placed in their proper sequence.

By way of illustrating the use of habitat types as a basis for sampling in stem decay problems I would like to recount some of the highlights of an investigation carried out by the Victoria Laboratory and in which consistent use was made of habitat types. The investigation to which I refer concerns a reappraisal in British Columbia of *Echinodontium tinctorium*, the Indian paint fungus. The purpose of this reappraisal was to provide a medium for predicting the occurrence of the fungus in different regions, localities, stands, and species, and at different levels of intensity. Prior to the reappraisal the fungus was known to occur in some regions and localities and in some species but the circumstances of its occurrence in any region, locality, or species were open to conjecture.

Some means of segregating province-wide forest cover into homogeneous categories was obviously required in this investigation in view of the range of forest habitats that characterizes British Columbia. Site classes in their conventional form were considered unsuitable as sample units for the reason that they had already proven to be insensitive to the variable occurrence that characterizes *E. tinctorium*. Similarly, forest types in their conventional form had already been tried and found insensitive to *E. tinctorium* variation. Clearly, some form of ecological site typing was indicated if a proper basis for distinguishing between habitat conditions was to be obtained. Consequently, a biogeographic classification of forest cover was carried out in eight distinct physiographic regions in British Columbia with the result that 53 habitat types became available for comparison with respect to the occurrence of *E. tinctorium*.

Each habitat featured at least one species of tree known to be susceptible to the fungus and most featured two or more. Some species occurred in many habitat types while others occurred in only a few. Disparity in the occurrence of individual species in the total list of habitat types in no way indicated that any one species was examined in any greater detail than another but, rather, was a true reflection of the natural occurrence of E. tinctorium suspects. Thus, the occurrence of western hemlock in 47 habitat types and of western white spruce in only six indicated nothing other than that western hemlock has a greater ecological tolerance in the area of study than does spruce. At the same time, in assessing the susceptibility of each species to infection it was obvious that western hemlock would require observation through a greater range of environmental conditions than would spruce. It is doubtful in my mind whether any system of forest classification, other than a biogeographical system, would automatically provide the necessary range of habitats for each species of suscept. Since the investigation called for this, I was satisfied to proceed on such a basis despite the fact of a large number of sample units with which to contend.

The results of the investigation were given, then, in terms of specific habitats, each of which was described so that it could be recognized in the field without difficulty. Thus, any peculiarity of E. tinctorium in relation to any of its suscepts could be considered first in the light of a specific habitat type and, later, in terms of localities, and regions. I am convinced that because of the kind of sample unit used it was possible to recognize more clearly the differences and similarities in E. tinctorium occurrence throughout the province than would have been the case had a less discrete kind of sample been used. The ability to observe these differences and similarities permitted habitat equivalents to be recognized when they occurred in different regions. Thus, equivalent conditions of E. tinctorium infection could be recognized.

The investigation brought to light some interesting facts among which was that the fungus occurs in many different habitat types and in all regions of British Columbia, including coast forests. Despite this, the fungus does not occur in a number of habitat types that include one or more of its suscepts, no species of suscept being infected in all of its natural habitats. Hence it can be concluded that the ecological tolerance of E. tinctorium is more restricted than that of its suscepts. At the same time, the fungus was found to have an ecological tolerance more closely allied to those of some of its suscepts than it does to others. Thus, the occurrence of amabilis fir habitat types is very nearly indicative of the occurrence of the fungus, whereas the occurrence of Douglas fir habitat types bears little relation to the occurrence of the fungus. This relationship was established for each species of suscept and, as the result, the occurrence of E. tinctorium can be forecast for the province, a region or a locality.

A further result of the investigation was a realization that the environment peculiar to a habitat type is, in fact, a composite of micro-environments, one of which may permit the fungus to occur in the habitat type and the others not. Consequently, most habitat types are heterogeneous to the extent that they represent more than one microhabitat. The similarities between different habitat types as regards the occurrence of E. tinctorium appear to result from the occurrence of similar micro-environments in different habitat types. For example, the micro-environment that permits E. tinctorium to occur in the tops of western hemlock in stands of a Vancouver Island habitat type is very similar to that which occurs in the tops of alpine fir and western white spruce in stands of a central interior habitat type. The existence of micro-environments within habitat types has further significance in that it helps explain the manner of occurrence of E. tinctorium within each habitat type. Thus you will find that in each habitat type the fungus occurs consistently either close to the ground, throughout the stem length of trees, or in the tops of trees. Conversely, the fungus will not occur close to the ground in one stand of a habitat type and in the tops of trees in another stand of the same habitat type.

A further result of the investigation was a realization that the most abundant occurrence of E. tinctorium in a region is coincident with reduced vigour of its suscepts, although not usually with their least vigorous condition. Keeping in mind that reduced vigour of suscepts stems from both overtopping and an inherent inability to occupy and develop satisfactorily in a specific habitat, it appears that sub-par vigour resulting from either condition is conducive to an increased occurrence of the fungus. The circumstances whereby suppression is an important factor as a conditioner to infection are limited to habitat types in which micro-environments favourable to infection extend into the lower canopies. On the other hand, inherent inability of a tree species to occupy and develop satisfactorily is a condition applicable to most habitat types. Hence, sub-par vigour stemming from such a direction is of considerable importance in relation to E. tinctorium infection. Since an estimate of the vigour of each plant species is required in the derivation of a habitat type, the association of a particular level of E. tinctorium infection with a particular habitat type automatically associates that level of infection to a known level of suscept vigour.

Another result of the investigation concerns the ratio of fruiting to infection, to the effect that in some habitat types infection regularly occurs without subsequent fruiting. This is in spite of the general high ratio of fruiting to infection that characterizes E. tinctorium and most of its suscepts. The circumstances under which infections occur, either without subsequent fruiting or with a low incidence of it, are limited to habitat types which contain a mixture of suspect species, at least one of which bears fruit bodies regularly. The few exceptions to this occur when fruit bodies are formed on the same or another suscept in nearby stands of the same or a different habitat. Engelmann spruce and western white spruce and the habitat types in which they occur are outstanding in their low ratios of fruiting to infection. The inoculum for infection of such species is obtained almost entirely from fruit bodies on alpine fir in the same or adjacent stands. Thus, inhibition of fruiting does act as a limiting factor to _E. tinctorium_ infection as, for example, in sub-alpine habitat types where the fungus is ordinarily confined to a limited portion of the habitat.

The foregoing comments represent a generalized account of only a few of the classes of information obtainable by the use of habitat types in sampling stem decay. I have not mentioned the factor of soil as an influence upon stem decay, a factor of considerable importance in that soil is a major conditioner of habitats as regards atmospheric humidity, suscept occurrence and suscept vigour. Data pertinent to the different features of soil are readily obtainable through a system of sampling based on habitat types. Similarly, the factors of air temperature and air humidity within a stand and that of wind influence are completely adaptable to investigation on the basis of habitat types.

The use to which habitat types were put in the reappraisal of _E. tinctorium_ in British Columbia represents an extreme test of this kind of sample unit by reason of the large number of sample units required. With investigations of less ambitious a nature the number of sample units need not be so large and the analysis of data, therefore, so cumbersome. Consequently, the large number of habitat types necessitated in some investigations need not deter a general use of this kind of sample unit. The use of habitat types as representing homogeneous units of vegetation and environment might be questioned in light of the existence of microenvironments within each habitat type. The existence of microenvironments cannot be ignored but satisfaction can be gained in the knowledge that each habitat type has its specific arrangement of microenvironments. Thus, all stands of a particular habitat type will exhibit the same pattern of variation from the ground line to the tops of trees. In this sense habitat types are homogeneous and all examples of any one habitat type represent a high degree of biotic similarity. With these convictions in mind, I can think of no better method of segregating total forest cover and the multitude of environments it represents than that of habitat types.

DECAY OF ASPEN IN COLORADO

by

Ross W. Davidson

Aspen (*Populus tremuloides* Michx.) stands are extensive in the central Rocky Mountain area, especially in the mountains and high mesas west of the Continental Divide in Colorado where the species reaches maximum development (2). On the better sites aspen yields a considerable volume of wood in a shorter period than do most of the conifers which grow at high elevations. The present study was undertaken as a preliminary survey to determine in some detail the relationship of decay to stands in different areas and of different ages.

Baker (2), who made a study of aspen in Utah, states that "It is found that while growth is more rapid in New England, deterioration and decay take place earlier, so that the maximum and average sizes are about the same in the two regions and stands are very similar". It is believed that growth is also somewhat more rapid in the better Lake States aspen but that deterioration is also more rapid there. Baker has set up a criterion of site quality based on height growth in Table 6. Thus height growth at particular ages may be checked against this table to determine site quality. He states that aspen grows on a wide variety of soil types but that soils and elevations as well as moisture affect the growth.

Review of Previous Work

Several previous studies have been conducted on decay in aspen and of these the results of Meinecke (7) should more nearly fit those of the present study. He attributes most of the rot in aspen in Utah to two fungi, *Fomes igniarius* and *Fomes applanatus*. *Fomes applanatus* is thought to enter through wounds at the base of the stems and although sporophores were seldom observed in connection with a distinct white to yellowish stringy butt rot, *Fomes applanatus* was tentatively assumed to be the cause.

Schmitz and Jackson (9) conducted a somewhat similar study of decay in eastern or Lake States aspen. Although their study was confined mainly to trunk rot caused by *Fomes igniarius*, they state generally that three fungi are usually considered the cause of the heart rot in aspen, *F. igniarius*, *Armillaria mellea*, and *Fomes applanatus*. Van Schrenk and Spaulding (10) point out that in New England, as well as in Colorado and New Mexico, it is almost impossible to find healthy stands of any age, due to *F. igniarius*.

Russian investigators have conducted many studies on aspen and especially on diseases or decay in aspen. Ankudinov (1) has given a rather extensive review of earlier work in Russia on this subject. There, many of the earlier papers have been concerned with the question of development of early symptoms of decay in young sprout stands. Some of those have assumed or concluded that red discolorations in very young stems were incipient infections by the decay fungus, F. igniarius, and that sprout stands were more subject to these early infections than were seedlings. However, Ankudinov brings out that more recent investigations show that the red discolorations in very young stands are not the result of decay infections and that sprout stands are not necessarily subject to more numerous infections by this fungus. He points out one study which concludes that better soil or sites do not necessarily give greater immunity of aspen to infection, but faster growth and acceleration of healing of wounds and knots may result in healthier stands. Stands should be fenced and systematic thinings should begin at 8 years, dead limbs pruned, and the rotation shortened to not over 40-45 years.

His own studies also indicate that aspen should be grown on a fairly short rotation. Examination of aspen on different sites indicated that the faster growing stands did not necessarily have less decay than certain poorer sites. Also there was no correlation of decay with crown class. These conclusions seem to have been based on percentage of trees with sporophores. He recommends control of density of stand and early thinning, sanitation practices, and selection of straight uninjured stems. However density should not be so reduced as to prevent early natural pruning of limbs. He recognizes the probable beneficial effect of artificial pruning of dead branches and subsequent, more rapid healing of "dry knots" but doubts whether pruning would in most instances be economically possible.

Besides the repeated emphasis of improvement cutting and removal of all trees with heart rot (sporophore of F. igniarius) Ankudinov suggests that age of final clear cutting for northern aspen be at about 60-70 years and in central or southern areas at 40-50 years. At time of cutting all logged products and slash should be removed before the appearance of the new coffice growth. All logged areas should be fenced to prevent cattle grazing in young sprout growth, where possible.

In the Russian studies, Fomes igniarius seems to be the decay fungus of economic importance.

Thomas and Podmore (11) published the results of studies on decay in black cottonwood in British Columbia. The fungi and decay encountered in their study indicated a distinct difference in that species as compared with aspen. In the cottonwood, Fomes igniarius was of no importance and Fomes applanatus was found only on dead trees. However, they did make a more complete study of the organisms and listed eight species as the cause of some volume loss in living trees. They also listed 70 species of fungi which cause some decay in cottonwood.

Location and Type of Stands Sampled

Samples for the present study were from the more important aspen stands on the western slope of the Continental Divide in Colorado. These stands are considered among the best in the region for commercial utilization purposes. It is believed that conditions in aspen will be somewhat similar immediately north, west, and south of the areas, but there may be some variations due to differences in temperature and moisture conditions.

The stands sampled were at an elevation of approximately 8,000 to 10,000 feet. At these elevations aspen occurs in almost pure stands except at the lower edge where amelanchier, scrub oak, and in some areas Douglas-fir and ponderosa pine may be interspersed, and at the higher elevations there is often a mixture of spruce and subalpine fir.

It is believed that the main factors favoring aspen are cool temperature and sufficient moisture. Good soil is of course necessary for maximum growth. The better aspen stands from northwestern Colorado to southeastern Colorado west of the Continental Divide support an abundant undergrowth of herbaceous plants. Forage for sheep is considered excellent under these better aspen stands.

Except for the above general conditions the requirements for aspen growth have not been studied in detail. Soil types, permeability, depth, and quality are factors needing investigation.

Methods Used in Aspen Study

An attempt was made to establish study plots in typical aspen in each area and in older and medium-aged stands. Isolated small patches of aspen were not sampled nor were stands at the lower elevations where growth was much lower than for the better stands.

One-tenth-acre plots were used except when time available made it necessary to obtain a smaller sample -- in which case 1/20-acre plots were used. In Table 1 the data is adjusted to plots of 1/10-acre size so the volumes and numbers of trees may be compared for each sample.

All trees 4 inches d.b.h. or larger were cut at 1-foot stump height, and at 4-foot intervals to a 4-inch top diameter. Where decay was encountered, the 4-foot bolts were further dissected to determine more accurately the extent of decay.

Samples were removed from most decay infections and an attempt made to isolate the organisms involved. Isolations were not as numerous as desired and for many cases there were failures to recover the fungus for positive classification. Also, time did not permit detailed study of all organisms isolated. The work did, however, give a better understanding of the fungi and serves as a basis for future more detailed study.

Age was determined from sample discs taken at stump height. In cases where butt rot made it impossible to secure an accurate age count, age was estimated on the basis of ages of adjacent trees of similar size.

Volume of wood was calculated for each 4-foot bolt by using Smalien's formula. Rot volumes were also calculated in the same way except that where rot ended within a bolt it was treated as a cone and volume calculated in the same way except the area of base x length was divided by three instead of by two.

RESULTS OF THE ASPEN STUDY

Stand History and Quality

Data on tree height and volumes indicate that aspen sampled was of site 1 and 2 quality in comparison with Baker's tables 6 and 17 (2). In most of the young stands, trees per acre was below the average given by Baker. However, height and total volume was equal or slightly above in a number of instances. Table 1 gives number of trees, average d.b.h., age and volumes for the present study. These may be compared with the figures given in Bakers paper. It should be remembered that where uneven aged stands were sampled, accurate comparisons cannot be made.

A detailed fire history for the aspen areas has not been available. However, the younger stands up to 80 years are approximately even aged and are assumed to have originated following fire. We are told that fires were extensive during the 1870's. In more limited areas there are stands 50 to 60 years old so we may assume that there were fires at later periods. There is considerable evidence that stands also originate from causes other than fire. For instance, many of the older stands (80 to 120 years or older) tend to break up due to over age associated with insects, disease, or drouth. These break ups sometimes result in fairly good sprout regeneration either as even aged growth or a sufficient thinning out of the older stems to permit sprouts to develop as an understory.

In several areas stands sampled were typically uneven aged. If fire was ever involved it was too remote to be apparent at the present time.

Decay As Compared To Total Wood Volume

One of the main objectives was to determine at what age decay and other defects become so important as to seriously reduce volume of sound wood, therefore, the necessity of keeping the samples to a definite area basis. Whether or not the sample used was of sufficient size for all purposes may be questioned, but for general acreage calculations, it should be fairly adequate.

Table 1. Data on One-tenth Acre Aspen Decay Plots

Plot Number	Number of trees	Age Average	DBH	Height Maximum	Volume Butt Rot	Volume Top Rot	Volume Total Rot	Total Volume Wood	Percent Butt Rot	Percent Top Rot	Percent Total Rot
Routt National Forest:											
16	50	70	8.1	76	3.7945	2.1362	5.9307	476.9	0.8	0.4	1.2
17	27 (54)*	69	7.6	62	0.6608	5.5419	6.2027	347.0*	0.4	3.2	3.6
19	25 13	115	12.8	73	5.7	58.1	63.8	277.9	2.0	21.0	23.0
	12	65	7.2		0.8	4.0	4.8	59.5	1.3	6.7	8.0
		85.7	10.1		6.5288	62.338	68.8668	337.3	1.9	18.5	20.4
18	19	114	12.3	79	0.8	7.7	8.4	448.3	0.2	1.7	1.9
20	10	107	14.2	75	0.8	0.0	0.3	299.9	0.1	0.0	0.1
21	10 (20)*	126	14.8	80	5.4	30.5	35.9	291.1*	1.9	10.4	12.3
White River National Forest:											
10	24	112	10.7	74	2.8	46.5	49.3	486.2	0.6	9.5	10.1
11	10	115	12.5	75.4	1.2	9.3	10.5	238.4	0.5	3.9	4.4
12	26	73	9.3	63	4.5	4.4	8.9	254.2	1.8	1.7	3.5
13	53	52	6.9	60	0.1	2.3	2.4	256.1	0.0	0.9	0.9
14	21 (84)*	53	5.2	43	3.2	2.6	5.8	151.1*	3.2	2.6	5.8
15	14 5	123	12.5	62	3.8	11.3	15.1	204.6*	4.1	12.2	16.3
	9	60	4.9		0.0	0.1	0.1		0.0	1.5	1.5

Plot Number	Number of trees		Age Average	DBH	Height Maximum	Volume Butt Rot	Volume Top Rot	Volume Total Rot	Total Volume Wood	Percent Butt Rot	Percent Top Rot	Percent Total Rot
Grand Mesa-Uncompahgre National Forest:												
1	60		66	5.8	45	0.2	2.4	2.5	113.6	0.2	2.0	2.2
2		10	130	14.0	67	3.4	63.3	66.7	280.1	1.2	22.6	23.7
	22	12	63.2	5.7	44	0.0	1.1	1.1	21.4	0.0	5.3	5.3
			81.9	9.0		3.4	64.4	67.8	301.7			
3	18	4	130	17.4	67	8.2	15.7	23.9	149.1	5.5	10.5	16.0
		14	66	6.8	52	0.1	1.3	1.4	68.4	0.1	1.9	2.0
						8.3	17.0	25.3	217.5	3.8	7.8	11.6
4	20		85.2	12.1	79	3.6	5.3	8.9	540.7	0.7	1.0	1.7
5	39		72.9	9.7	62	0.7	10.7	11.4	488.1	0.1	2.2	2.3
6	28		77.2	10.0	64	14.6	5.1	19.6	365.7	4.0	1.0	5.0
7	28		82.4	10.4	69	0.8	13.7	14.6	420.9	0.2	3.3	3.5
8	37		135	18.2	66							
			57.0	6.3	66	67.4	11.8	79.2	448.0	15.0	2.7	17.7
9	21		119	12.0	72	26.7	12.7	39.4	442.1	6.0	2.9	8.9
1	39	16	150	17.3	83.6	136.3	4.3	140.6	811.2	16.8	0.5	17.3
		23	63	6.1	56	2.9	1.8	4.6	89.6	3.2	2.0	5.2
						139.2	6.1	145.2	900.8	15.5	0.7	16.1
2	18		161.5	15.8	94	75.6	49.9	125.6	833.9	8.9	6.0	15.0
3	30		74	8.8	81	0.2	0.0	0.2	493.7	0.0	0.0	0.0

Plot Number	Number of trees	Age Average	DBH	Height Maximum	Volume Butt Rot	Volume Top Rot	Volume Total Rot	Total Volume Wood	Percent Butt Rot	Percent Top Rot	Percent Total Rot
Gunnison National Forest:											
10	35 12	129	13.8	69	8.5	72.5	81.0	328.8	2.6	22.0	24.6
	23	66	6.6	55	1.1	4.5	5.7	75.4	1.5	6.0	7.5
		88.6	9.1		9.6	77.0	86.7	404.2	2.4	19.0	21.4
11	17	125	11.7	73	26.2	32.9	59.0	369.0	7.1	8.9	16.0
12	25 6	130	14.3	79	1.5	11.7	13.1	200.7	0.7	5.8	6.5
	19	66	7.2	75	3.6	6.2	9.7	174.3	2.0	3.5	5.5
		84	9.4		5.1	17.8	22.9	375.0	1.3	4.8	6.1
13	34	77.4	10.5	79	4.8	6.9	11.7	620.9	0.8	1.1	1.9
14	35	(61)58	8.2	68	0.5	(46.5)	(47.0)	343.0	0.1	4.9** (13.6)	4.9** (13.7)
San Juan National Forest:											
4	25	68	9.7	69	7.9	10.7	18.6	321.2	2.5	3.3	5.8
5	27	72	9.9	69	1.6	4.2	5.8	380.4	0.4	1.1	1.5
6	32	153	10.7	75	9.8	53.0	62.8	566.1	1.7	9.4	11.1
7	49 27	73	9.8	77	5.3	0.0	5.3	406.6	1.3	0.0	1.3
	22	41	6.7	68	0.0	1.0	1.0	123.8	0.0	0.8	0.8
					5.3	1.0	6.4	530.4			
8	19 (76)*	52	6.0	57	3.7	4.3	8.0	266.9*	1.4	1.6	3.0
9	11 (22)*	152	11.8	76	12.4	98.1	110.5	492.7*	2.5	19.9	22.4

* These tree numbers and volumes have been adjusted to a 1/10-acre plot size.
All other plots were on a 1/10-acre basis.

** Adjusted to age of stand.

In Table 1 there is given most of the basic data on all plot samples. Some plots were not in even aged stands and here it was necessary to divide the plot-decay-volume data by two age groups. In most such cases the total volume of wood per sample plot is also given. In order to show the age decay relationship the decay volumes have been rearranged in chart form (Figure 1, A&B). This chart will show the general trend of only a small percentage of decay at 41 to 60 years to very moderate amounts at 70 and 80 years. There is a lack of data on the 80 to 90 year period but beginning at about 100 years the percent of decay volume is considerable in most stands.

The decay age data has been kept to a plot sample basis here because of certain extreme variations. Some of these variations can be explained but others cannot be explained with any degree of certainty. For instance, the extremely high butt rot volume from some of the older plots is due to decay following fire wounding about 80 years ago. Some of these old wounds were still open and extended to a considerable height on the trunks. In other older stands the wounds had not been so severe and although decayed, had become almost completely healed over in the 80-year period. Fire wounds were not common in any of the stands under 85 years.

Some of the unexplained variations may be pointed out by reference to plots 18, 19, 20 and 21 on the Routt National Forest. All of these were in stands over 100 years in age. Plots 18 and 20 from the same stand, contained less decay than most stands of much younger age. Plot 21 was in a stand only 150 yards from the above two plots but in general appearance seemed different in that trees were not as straight and bark was of the so-called whiter type. There were probably differences in stand origin, also, although such differences are somewhat speculative at the present time. One of the main reasons for differences in rot volume was in absence of *Fomes igniarius* var. *populinus* in the one stand and its presence in the others.

Two other older plots showed few *F. igniarius* var. *populinus* infections, these were plots 1 and 2 at the southermost edge of the Uncompahgre National Forest. Plot 1 had no identifiable infections by this fungus, and plot 2 had no *F. igniarius* var. *populinus* sporophores but two identifications were made by isolation of the organism. The main question raised here is whether the samples were too small to give reliable rot volume data. Probably some other sampling method should be used to show conclusively that there is much less of this fungus in some older stands.

Aspen Decay Fungi

Fungi isolated or otherwise identified are listed in Table 2, with the total trees sampled. The total number of trees sampled on the 35 study plots was 958. Some of the fungi listed require further study for more complete identifications and there are others which probably cause decay but have not been identified.

Table 2. Aspen Decay Fungi

Fungus	Number of infections identified	Percent of trees sampled	Total volume of decay	Percent of decayed wood in trees infected	Average d.b.h. of trees infected
			(cu ft)		(inches)
Cryptochaete polygonia	113	11.4	68.7	5.9	9.1
Fomes igniarius var. populinus	102	10.6	472.1	25.1	11.1
*Callybia velutipes	46	4.8	65.5	7.4	11.6
*Fomes applanatus	33	3.4	49.1	10.1	10.6
*Pholiota squarrosa	16	1.7	20.2	5.6	12.2
*Coniophora ? (brown butt rot)	12	1.3	?	?	?
*Pleuratus	6	--	--	--	--
*Trechispora raduloides ?	5	--	--	--	--
*Armillaria	3	--	--	--	--
Polyporus dryophilus var. vulpinus	3	--	--	--	--
*Polyporus adustus	3+	--	--	--	--
Daldinia concentrica	2	--	--	--	--
*Lyophyllum unifactum ?	1	--	--	--	--
Total	345	35.8			

* Butt rot fungi

Decays are usually divided into butt rots and trunk rots. In aspen there are a number which are confined for the most part to the butt area and others mostly to the trunks. In this study all Fomes igniarius var. populinus and Cryptochaete were classified as trunk rots although in quite a few cases, especially of F. igniarius var. populinus, the rot was concentrated in the butt of the tree. Callybia velutipes was usually isolated from butt rot but is known to get into wounds in tops of some tree species.

Of the four species here classified as from trunk decay, Cryptochaete polygonia (6) was isolated and identified from more decay infections than any other. Since it does not fruit readily on infected living trees, it could be identified only from isolations. There were many additional decay infections which appeared to be caused by Cryptochaete but which were not positively identified because of failure to obtain a culture or the isolate was of a secondary non-decay species.

Decay with which Cryptochaete was associated was white and often with a red brown margin. However, the marginal coloring was not consistently present and did not appear to be caused by Cryptochaete. The decay was usually more typically of an incipient stage and never appeared to be in an advanced stage of disintegration. It was especially noticeable on cross cuts with a power saw. The infected wood seemed more brittle than normal wood and fibres were sort of pulled out rather than cut cleanly.

Entrance was almost entirely through branch stubs and infections were sometimes fairly low in the trunk and sometimes in the upper or crown area. Incipient infections of F. igniarius var. populinus could not be separated from those of Cryptochaete unless the black marginal line so characteristic of the former had started to develop. The volume of rot caused by F. igniarius var. populinus was much greater than for any other of the decay species. Also, volume of decay per tree infected was much greater. In young stands, up to about 80 years, percent of trees infected by this fungus was low and also volume of rot per tree infected was also low; whereas, percent of trees infected by Cryptochaete was high in a number of the young stands.

Polyporus dryophilus var. vulpinus was isolated only three times. These infections were from older trees. It caused a white pocket rot of the trunk.

Daldinia concentrica was present in two living trees but it seems doubtful as to whether it causes much decay.

Fungi isolated from butt decay are more numerous although total number of infections and total butt rot volume was probably less than for trunk rot. Fomes applanatus seems to be by far the most important of the butt rots chiefly because of its root parasitism and subsequent dripping out of trees infected by it.

Rot caused by it is white mottled and it was consistently concentrated in the large roots and basal part of the stem. In almost every area sampled and many that were not sampled numerous trees were seen that had blown over while still alive. When examined, almost all of such down trees had the roots rotted off by F. applanatus on one side. The decay usually does not extend up very far above stump height. It affects the sapwood as well as the heartwood. The method of infection by it is now known in detail but conspicuous wounds were not associated with the infections.

Decay attributed to Callybia velutipes had a larger total volume than any other butt rot. It was identified from cultures more frequently than any other. There is some question as to whether it was actually the cause of most of the decay with which it was associated. Usually it was associated with white rot but there were a few exceptional cases.

Pholiota squarrosa and F. applanatus decay were somewhat similar in their incipient stages so that in a number of infections where the rot was suspected of being F. applanatus the isolations turned out to be Pholiota. Entrance of both seems to be through the roots but Pholiota does not act as a parasite to the same extent as does F. applanatus and does not result in weakening and subsequent windthrow.

Pholiota was frequently found fruiting on the ground at the base of infected trees. Lyophyllum unifactum ? was also found fruiting on the ground at the base of an infected tree. Cultures from the sporophores and from the rot in the tree were the same. It is possible this fungus is of greater importance than the one case indicates because cultural characteristics are not or were not known during the course of the study. Decay by it is somewhat similar to that of Pholiota.

Brown butt rots as previously stated were fairly common, in young stands, especially. Some of the cultures obtained from the brown butt rot were fairly typical of Coniophora puteana but have not been studied with sufficient thoroughness to be absolutely sure of their identity. In a few cases cultures isolated were of other decay species but they were not identified.

Armillaria was isolated several times and appeared to be present occasionally as small pockets of rot associated with basal wounds. It should be considered in any further study of root rot organisms It is possible that it may be one of the parasitic species --killing roots or injuring them so that other faster growing decay species can get into the trees. However, in this study it did not appear to be an important species.

Polyporus adustus ? occurs as a sap rot associated with wounds but was not isolated from typical heart rot. Pleurotus sapidus was isolated from six trees. In most of these cases it was present as a heart rot in the lower part of the trunk and decay was fairly extensive.

One fungus which gained considerable attention during the past summer was one frequently associated with a white mottled rot in the tops of the trees. Quite frequently it was isolated from decay having an odor similar to that from green walnut hulls. The odor may be more a host reaction to a particular type of injury. In any event, the fungus was tentatively determined as being isolated from 40 trees with top decay. The cultures have a rather dense white to buff cottony mat with some dark mycelium on or in the substratum. It is believed to be an ascomycete but so far no fruiting stage has been observed.

Sporophores of Aspen Decay Fungi

Most trees with extensive F. igniarius var. populinus decay had conspicuous fruiting bodies on the trunk. The number of such fruiting bodies, which usually form at old branch stub traces, is an indication of the longitudinal spread of decay inside the trunk.

F. applanatus fruiting bodies are usually present on the bases of infected living trees but are often so near the base as to be partly hidden by grass or herbaceous plant growth. Fruiting bodies continue to develop after the infected trees fall over.

As was previously stated, sporophores of Pholiota frequently develop on the soil at the base of infected trees. This fungus seems to grow from a dead root or other defect underground and fruits from a mass of mycelium which develops as a sort of pseudo sclerotium in the surrounding soil. The sporophores are annual and disintegrate within a few months after development. Lyophyllum unifactum ? develops in the same way at the base of the tree (only one case observed).

Pleurotus sapidus and Collybia relutipes frequently fruit on dead standing or down trees but were not seen on living trees. The latter were most frequently formed at the base of the trunks or from underground dead roots.

Daldinia concentrica was present on one living tree. It had grown from a branch stub trace at considerable height on the trunk. The decay inside the trunk seemed to be mostly caused by F. igniarius var. populinus.

Cryptochaete fruits in abundance on recently fallen trees with the bark still on and only occasionally on dead stubs of living standing trees.

Coniophora puteana has been collected on aspen logs occasionally but not on living trees. This is also true of Polyporus adustus although this fungus is also present as a wound saprophyte occasionally.

Sporophores are very useful as visible evidence of high or low decay incidence. Some estimate of volume can also be obtained in older stands by tallying the number of trees with sporophores. Trees infected by F. igniarius var. populinus in the present study had an average of 25 percent decayed wood. As this figure contained numerous incipient infections in young trees, the volume of decayed wood in the older stands where sporophores are present would be somewhat higher.

Conclusions on Decay Fungi

At the start of this aspen decay study in 1954 we thought that Cryptochaete had not been reported from aspen heart rot before or that it was present only in this central Rocky Mountain area. When Dr. Nordin was in Colorado last July, he asked whether I had seen several interim reports on decay of aspen in Canada. He said he would send copies of these reports. These were received later.

One report by R. F. Black (3) was on Decay in Aspen in the Upper Pic region of northern Ontario dated June 1951. Another by Black and Bourchier (4) was on Decay in Aspen in the Manitoulin area of Ontario dated July 1952. The third was by Black and Knstapovich (5) on Decay in Aspen in Manitoba and Eastern Saskatchewan and dated April 1954. I am not sure as to whether any of these has been published.

In the first of these studies, sixteen species of fungi were listed. Ten were butt rots and six were trunk rots.

In the 1952 Ontario study, ten named fungi are listed with eight of them top rots and only two as butt rots. Corticium polygonium (Cryptochaete) was isolated 7 times as compared to 167 cases of Fomes igniarius var. populinus. The authors consider this the first report of C. polygonium as a heart rot.

The 1954 paper from Manitoba and Saskatchewan listed nine trunk rot fungi and three from butt rot. There were 124 C. polygonium as compared to 215 of F. igniarius var. populinus. In all three studies the fungus Radulum casearium is listed as second to F. igniarius var. populinus in importance. It has not been identified from Colorado but possibly it may be one of the unidentified isolates. Another big difference is that Fomes applanatus was not reported in any of the three studies.

The present study and those of Black and coworkers in Canada show that there are more decay fungi involved and that the disease condition in aspen in general is more complicated than earlier studies had indicated. F. igniarius var. populinus is important, in Colorado at least, because of the presence of older and somewhat overmature stands. If aspen can be managed on a 70 to 80 year rotation, decay fungi other than F. igniarius may be of much greater importance.

In the present study where many of the stands originated following fire decay entrance from parent stumps did not seem to be important. If stands of the future originate following clear cutting, decay from parent stumps probably could be of some importance.

Some observations were made of stands in the process of breaking up. Decay or root rot did not appear to be involved in such break up but further studies are needed by both entomologists and pathologists before a clear picture can be obtained. Bark and wood borers are sometimes present in great abundance in stands that are breaking up but it is not known whether they are secondary or primary.

Stand history is also believed to be an important factor in high or low incidence of decay but the factors responsible are not known.

In other words, the study made gives some ideas on the amount of decay in stands of different ages but much more detailed information is needed before we shall know just how decay gets started and whether management practices can be devised to reduce rather than encourage decay.

Wetwood and Associated Defects

Wetwood is a common defect in many hardwood tree species. In some stands of aspen wetwood infections were common to abundant. In some there were very few. In the present study it was not possible to obtain any definite data on its possible influence on decay. In several instances wetwood infections were abundant and decay infections and volumes were low.

In plot 16 on the Routt National Forest where wetwood infections were abundant, they appeared to have resulted in prominent frost cracks. In most cases there was conspicuous sap flow from the frost cracks. It was thought that the frost cracks were a direct result of wetwood infections but the absence of frost cracks in other stands where wetwood was common is difficult to explain. Trees on plot 17, about 3 miles from plot 16, were of a similar age, but of somewhat slower growth, contained no frost cracks. According to our records, 36 trees on plot 16 had wetwood infections of which 17 had frost cracks whereas 22 trees on plot 17 had wetwood and none had frost cracks.

Wetwood was often associated with wounds of various types in which cases there was often decay present also. Perhaps the most frequent association was wood borers and wetwood in which case decay was seldom present. It has been shown that bacteria are often present in wetwood infection and they are assumed to be the direct cause. In the aspen study a number of isolations were made from wetwood. In some such instances bacterium-like growth was obtained but in others no bacterium was detected. The wetwood situation in aspen would seem to require a more intensive study for better understanding of its role in pathology of the host.

Rocky Mountain Forest and Range Experiment Station, Forest Insect and Disease Laboratory at Colorado State University, Fort Collins, Colorado.

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APPENDIX I

NEW PROJECTS

A. FOREST DISEASE SURVEYS - General

1. Project Title: Forest disease conditions in California.

   Project Leader: J. W. Kimmey

   Objectives: To make annual evaluation of forest disease conditions.

   Present Status: Active

   Publications: Forest disease conditions in California. Calif. Forest & Range Exp. Sta. U. S. Forest Service Mimeographed. 8 pp. 1956.

B. NONINFECTIOUS DISEASES

   None

C. CONE, SEED, AND SEEDLING DISEASES

   None

D. ROOT AND SOIL DISEASES OR RELATIONSHIPS

1. Project Title: Influence of mycorrhiza on the survival and subsequent development of Douglas-fir seedlings.

   Project Leader: J. E. Bier

   Objectives: To determine the role of mycorrhiza in the germination, growth, and survival of Douglas-fir seedlings in nurseries and plantations.

   Present Status: Exploratory

   Publications: None

2. Project Title: Effect of artificially imposed moisture stress on rootlet mortality of seedlings of western white pine and associate species.

   Project Leader: Charles D. Leaphart

Location of Laboratory: Intermountain Forest and Range Experiment Station, Forest Service, U.S.D.A., Spokane, Washington.

Objectives: To determine the effect of soil-moisture deficiency on rootlet mortality and root development of western white pine, western larch, western red cedar, grand fir, and Douglas-fir seedlings grown on three types of soils--one having rocky subsoil, one having a deep, well-drained subsoil, and one having a hard-pan subsoil.

Publications: None

3. Project Title: Root distribution and condition of the root systems of tree species in western white pine stands.

Project Leader: Charles D. Leaphart

Location of Laboratory: Intermountain Forest and Range Experiment Station, Forest Service, U.S.D.A., Spokane, Washington.

Objectives: To determine the structural root and the rootlet abundance, distribution, and characteristics of tree species in western white pine stands. Particular attention will be devoted to western white pine, grand fir, western hemlock, western larch, western red cedar, Douglas-fir, Engelmann spruce, and lodgepole pine whenever these species occur within sampling units. Disregarding physiological aspects of the problem, the aim is to compare the competitive ability of white pine to the above-mentioned species on the basis of root habit, structure, etc.

Publications: None

E. FOLIAGE DISEASES

None

F. STEM DISEASES - Malformations, witches brooms, dwarfmistletoes, etc.

1. Project Title: Dwarfmistletoe of ponderosa pine.

Project Leader: Keith Shea
Weyerhaeuser Timber Co., Forestry Research Center, Box 420, Centralia, Washington.

Objectives: To determine the biology, damage, and control.

Publications: None

2. Project Title: Distribution and damage surveys of the dwarfmistletoes.

Project Leader: Donald P. Graham

Location of Laboratory: Intermountain Forest and Range Experiment Station, Forest Service, U.S.D.A., Spokane, Washington.

Objectives: The primary objectives of this survey are to determine the abundance and intensity of dwarfmistletoe and the amount and rate of damage with reference to possible correlated factors such as forest type, site class, site, density and topography. This information will assist in development of control practices to reduce the losses that occur.
It is planned to accomplish these objectives by combined roadside and plot surveys. The early effort will be concentrated in the western larch and Douglas-fir timber types on the Colville and Nezperce National Forests.

Publications: None

G. STEM DISEASES - Stains and decays

1. Project Title: Heart rots of young-growth Douglas-fir.

Project Leader: George M. Harvey
Pacific Northwest Forest and Range Experiment Station, P.O. Box 4059, Portland 8, Oregon.

Objectives: (1) To obtain detailed information on factors involved in establishment and growth of heart-rotting fungi, with special reference to reduction of losses. (2) To determine the life expectancy of the tree and the extent of decay associated with the various external indicators. (3) To determine the magnitude, rate, and distribution of damage by heart rots.

Present Status: This is an old project that has received little attention during recent years. We have dissected trees in several localities and are almost ready to publish some of our general observations, but much more work will be necessary for completion of the study.

Publications: Childs, T.W. Bear damage to young Douglas-fir. Pac. N.W. For. Exp. Sta. Research Note 113. 4 pp. illus. April 1955.

Childs, T.W. Pruning and occurrence of heart rot in young Douglas-fir. Pac. N.W. For. Exp. Sta. Research Note 132. 5 pp. July 1956.

2. Project Title: Decay of lodgepole pine.

Project Leader: Ernest Wright
Pacific Northwest Forest and Range Experiment Station, P.O. Box 4059, Portland 8, Oregon.

Objectives: (1) To ascertain the volume loss due to decay and other defects. (2) To identify the fungi causing decay. (3) To determine the common entrance ports for decay fungi.

Present Status: Study initiated this summer and preliminary data ready for tabulation. Cultures obtained of the principal decay fungi.

Publications: None

3. Project Title: Decay of Pacific Coast alder.

Project Leader: Ernest Wright
Pacific Northwest Forest and Range Experiment Station, P.O. Box 4059, Portland 8, Oregon.

Objectives: (1) To determine the principal fungi causing decay. (2) Determine the importance of decay.

Present Status: Cultures ready for identification and preliminary records on extent of decay obtained.

Publications: None

4. Project Title: Decay following logging injury to western hemlock, Sitka spruce and true firs.

Project Leader: Ernest Wright
Pacific Northwest Forest and Range Experiment Station, P.O. Box 4059, Portland 8, Oregon.

Objectives: To develop a formula for estimating the amount of decay in partially logged stands.

Present Status: The first major phase of this study has been completed. A formula and tables have been presented to determine the amount of decay in a logging-damaged stand on the basis of position and size of the logging scars.

Publications: Wright, Ernest and Leo A. Isaac. Decay following logging injury to western hemlock, Sitka spruce and true firs. USDA Tech. Bul. 1148. 34 pp. illus. 1956.

Code: 52.01.01.A5

5. Project Title: The fungi associated with decay of Douglas-fir and western yellow pine in the interior region of British Columbia.

Project Leader: A. C. Molnar
Forest Biology Laboratory, Victoria, B.C.

Objectives: (1) To determine the fungi associated with decay of living Douglas-fir and yellow pine in the interior region of British Columbia and attempt to relate their occurrence with site factors. (2) To determine the fungi associated with sap-rots of felled Douglas-fir and yellow pine and measure their rates of penetration.

Publications: None

H. STEM DISEASES - Rusts and cankers

1. Project Title: Testing sequential sampling techniques for surveys of ribes populations and rust damage.

Project Leader: H. R. Offord
California Forest and Range
Experiment Station, Berkeley, California

Objectives: To compare the costs and efficiency of sequential sampling and continuous transect survey methods where distribution pattern of the pest is generally known.

Present Status: Sequential sampling curves based on a negative binomial distribution of a light ribes population were devised and tested in the field. Differences of one ribe per acre at the 90 percent level of probability were determined by 15 random plots in place of the 64 plots used by the continuous transect system.

Publications: None

2. Project Title: Ribes ecology in relation to blister rust control and whire pine management.

Project Leader: C. R. Quick and V. D. Moss
California Forest and Range Experiment Station, Berkeley, California and Inland Empire Research Center, Spokane, Washington.

Objectives: (1) To study the germinative response of ribes seeds and their viability under different conditions of natural storage. (2) To determine the survival and growth rate of ribes in various vegetative communities and measure the impact of fire, logging, and other disturbances on the regeneration of ribes. (3) To analyze site and climatic factors affecting the re-establishment and growth rate of ribes in relation to prescribed standard for their suppression in blister rust control.

Present Status: Work has been in progress for many years in western white pine areas of northern Idaho and in sugar pine areas in California. Studies are now being extended to ribes of economic importance to the blister rust program in southern Oregon. Findings from these studies are being used in control operations to determine the most effective eradication schedules and the standards of ribes suppression to be prescribed.

Publications: Moss, Virgil D. and Charles A. Wellner. Aiding blister rust control by silvicultural measures in the western white pine type. USDA Cir. No. 919. 32 pp. illus. 1953.
Quick, Clarence R. Ecology of the Sierra Nevada Gooseberry in relation to blister rust control. USDA Cir. No. 937. 30 pp. illus. 1954.
_______________. Viable seeds from the duff and soil of sugar pine forests. Forest Science 2(1):36-42. 1956.

3. Project Title: Development and improvement of chemical methods for the eradication of ribes.

Project Leader: C. R. Quick and V. D. Moss
California Forest and Range Experiment Station, Berkeley, California and Inland Empire Research Center, Spokane, Washington.

Objectives: To test new herbicides and new formulations and methods of applying these formulations to ribes under field conditions.

Present Status: Work has been in progress for 30 years in northern Idaho and California. From these studies have come effective and economic methods of ribes control that have been in practical use since 1928. Methods and herbicides have been improved from year to year. Most recent improvements related to (1) concentrations and dosages of 2,4-D and 2,4,5-T needed for effective basal stem treatments, (2) the use of superfine white pine wood flour as a marker for sprays used out of power rigs in northern Idaho, and (3) the use of specially prepared clay pellets containing volatile esters of 2,4-D for killing ribes seedlings and crown sprouts.

Publications: Offord, H. R., V. D. Moss, W. V. Benedict, H. E. Swanson, and A. London. Improvements in the control of ribes by chemical and mechanical methods. USDA Cir. No. 906. 72 pp. illus. 1952.
Manuscript by Offord, Quick, and Moss in preparation for the Journal of Forestry.

4. Project Title: Distance of spread and rust losses to sugar pine associated with prescribed control standards (ribes populations).

Project Leader: D. R. Miller
California Forest and Range Experiment Station, Berkeley 1, California

Objectives: (1) To determine the amount of rust occurring within representative sugar pine control units by periodic check of number and age of cankers on permanent sample plots. (2) To appraise this attritional loss or damage to sugar pine in the light of the ribes population as shown by regular operations check of the plot and its contiguous pine area. (3) To determine for two special enlargements of these small sample plots the effectiveness of a 10-chain (California) and a 20-chain (Oregon) buffer strip.

Present Status: Sixteen 1-acre sample plots and seven 1/5 acre plots have been established in sugar pine type of Oregon and California since 1944. All white pines and ribes on the plots are mapped by plane table, and a case history of infection on pine and ribes has been recorded by code on IBM punch card. A check is made for ribes after each eradication working by regular control crews and each plot is given a 100 percent check for pine infection about every 3 to 5 years. Reports on rust losses are prepared and submitted to control supervisors after each pine inspection.

5. Project Title: Relationship of the spread and intensification of the blister rust disease of western white pine in the Inland Empire Area to the microclimate.

Project Leader: Merle G. Lloyd

Location of Laboratory: Intermountain Forest and Range Experiment Station, Forest Service, U.S.D.A., Spokane, Washington.

Objectives: To investigate the effect of microclimatic factors on infection, intensification, and spread of blister rust of western white pine. An understanding of these effects should aid in the control of the disease by determining source of sporidia, necessary protection zones, ribes tolerance, and other importance information.

Publications: None

6. Project Title: Etiological, host-parasite, and ecological investigations of the Atropellis disease of lodgepole pine.

Project Leader: Dr. J. C. Hopkins
Forest Biology Laboratory, 102-11th Ave., Calgary, Alberta.

Objectives: (1) To determine the influence of temperature and pH on the growth of the Atropellis fungus in culture. (2) To determine growth factor requirements, carbon and nitrogen sources and their effect on growth in culture, etc. (3) To determine the exact cultural characteristics of one or more isolates under a range of cultural conditions.

Publications: Hopkins, J.C. Studies on the Atropellis canker disease of lodgepole pine in Alberta. Mimeographed. Interim Report, Forest Biology Laboratory, Calgary, Alberta. March, 1957.

I. WILT AND BLIGHT DISEASES

1. Project Title: Dieback of immature (sapling) Douglas-fir in coastal British Columbia (subproject of 53-A-3).

Project Leader: W. A. Porter
Forest Biology Laboratory, Victoria, B.C.

Objectives: To investigage a condition of top-dying of young Douglas-fir.

Publications: None

J. DEFECTS AND DECAYS OF FOREST PRODUCTS - Dead Timber, Slash, etc.

1. Project Title: Decay of killed Douglas-fir in interior British Columbia.

   Project Leader: G. P. Thomas
   Forest Biology Laboratory, Victoria, B.C.

   Objectives: (Tentative) To determine the nature and progress of deterioration in Douglas-fir killed by various agents.

   Publications: None

2. Project Title: To determine the rate of deterioration of western hemlock logs in cold decks.

   Project Leader: Ernest Wright
   Pacific Northwest Forest and Range Experiment Station, P.O. Box 4059, Portland, Oregon.

   Objectives: To determine if sprinkling retards decay.

   Present Status: First test just concluded. Results indicate that sprinkling does retard decay in both fresh and buckskin logs.

   Publications: None

3. Project Title: Deterioration of beetle-killed Douglas-fir in the Pacific Northwest.

   Project Leader: Ernest Wright
   Pacific Northwest Forest and Range Experiment Station, P.O. Box 4059, Portland, Oregon.

   Objectives: To determine rate of deterioration in relation to age class.

   Present Status: This project is still in progress. The object is to determine the rate of deterioration of standing beetle-killed timber to aid salvage logging. Rate of deterioration varies according to tree diameter and age. Young trees with a high percentage of sapwood show the most decay. Sapwood decays just as rapidly in large old trees, but because of its small volume in relation to heartwood, the loss is less serious on a total volume basis. It takes about 4 years before the sapwood is a commercial loss, and the heartwood is invaded by decay in about 6 years. Fomes pinicola causes the greatest volume of decay. Decay of the sapwood increases breakage during felling and is closely correlated with the position of the Dendroctonus galleries.

Publications: Wright, Ernest and Wright, Kenneth H. Deterioration of beetle-killed Douglas-fir in Oregon and Washington. Pacific Northwest Forest and Range Expt. Sta. Research Bul. 10. June 1954.

4. Project Title: Deterioration of beetle-killed Pacific silver fir.

Project Leader: Ernest Wright
Pacific Northwest Forest and Range
Experiment Station, P.O. Box 4059,
Portland, Oregon.

Objectives: To determine the deterioration rate of Pacific silver fir killed by Pseudohylesinus beetles.

Present Status: Pacific silver fir is principally used for pulp, because of its known non-decay-resistant-heartwood, information was needed as to how long beetle-infested trees are utilizable. It was found that by the end of 4 years the heartwood was appreciably decayed, and between 30 and 40 percent of the volume was lost to decay. Fomes pinicola is the principal decay fungus, but Stereum chailetii is important in the decay of sapwood. Armillaria mellea may assist in weakening the trees prior to infestation.

Publications: Wright, E., W. K. Coulter and J.J. Gruenfeld. Deterioration of beetle-killed Pacific silver fir. Jour. of Forestry 54(4):322-325. 1956.
Gruenfeld, J.J., E. Wright and W. K. Coulter. Operation counterattack. The Timberman LVII:12, 1956.

K. MISCELLANEOUS STUDIES

1. Project Title: Exotic plantation studies (52.01.01A4).

Project Leader: A. C. Molnar
Forest Biology Laboratory, Victoria, B.C.

Objectives: To catalogue the plantations of non-indigenous tree species in British Columbia and carry out periodic examinations to evaluate their pathological conditions.

Publications: None

2. <u>Project Title</u>: Disease surveys and pathogenicity tests on selected clones of poplar, including introduced varieties.

<u>Project Leader</u>: J. E. Bier
Dept. of Biology and Botany, Univ. of British Columbia, Vancouver 8, Canada.

<u>Objectives</u>: To conduct disease surveys and test different diseases on clones of black cottonwood for development of resistant clones for propagation. The study is to test both native and introduced varieties.

<u>Publications</u>: None

APPENDIX II

CHANGES IN OR TERMINATION OF PROJECTS

1. 54-D-1 - <u>Phytophthora lateralis</u> survey.

   <u>Project Leader</u>: John Hunt

2. 54-H-3 - White pine blister rust.

   <u>Project Leader</u>: George M. Harvey

3. 54-H-6 - The differentiation of telia of <u>Cronartium ribicola</u> and <u>C. occidentale</u>.

<u>Summary of findings</u>: Two new methods have been developed which give good differentiation between <u>Cronartium ribicola</u> and <u>C. occidentale</u> in the telia stage. The first procedure involves the use of bromophenol blue indicator solution which is prepared in .001 M solution at pH 3.5. The second procedure makes use of acid fuchsin stain buffered at pH 4.8. Color differences in the second procedure are observable with the naked eye making it possible to utilize the method in field determinations of rust specimens.

APPENDIX III

NEW AND MODIFIED TECHNIQUES

1. Portable Electric Refrigerator.

Submitted by: R. V. Bega

Address: California Forest & Range Experiment Station, Berkeley, California

Technique: A portable Astral refrigerator was used in white pine blister rust microclimate studies this year. It is 2 x 2 x 2 feet, weighs 60 lbs., and has an interior capacity of 1.4 cubic feet. A dual voltage kit supplied with the refrigerator allows it to be operated on either 110-115 volt AC or on a 6 volt DC automobile battery.

Its small size and the fact that it will operate off of the current from an automobile battery make it very useful in field studies where the researcher is away from the laboratory for extended periods. Culture media, cultures, specimens, etc., can be collected and refrigerated on the spot.

In the current field work the unit was kept in the automobile at all times; therefore, telial material could be collected and refrigerated immediately without fear of its dying out or becoming inviable before it could be tested for viability.

2. Portable Hygrothermograph Shelters.

Submitted by: R. V. Bega

Address: California Forest & Range Experiment Station, Berkeley, California.

Technique: Portable hygrothermograph shelters were used this year for the first time in connection with the white pine blister rust microclimate studies. The shelters are made of aluminum, measure 20 inches long by 8-1/2 inches wide by 12 inches high and weigh 9-1/2 lbs., empty or 18-1/2 lbs. with the hygrothermograph inside.

The small size and light weight allow several shelters to be transported in a vehicle at one time. In the current season projects, 8 instruments and shelters were used and all 8 were carried in a sedan delivery automobile along with other field laboratory equipment, including microscopes, culture media, portable refrigerator, etc.

Another very useful purpose is in portage over rough terrain or for long distances. Two or three shelters with instruments inside can be carried easily by one man.

The original plans were supplied by the Forest Fire Laboratory, Missoula, Montana. Slight modifications were made in accordance with our needs.

3. An improved field form for permanent plot work.

Submitted by: J. W. Kimmey

Address: California Forest & Range Experiment Station, Berkeley, California

Techniques: A field form for recording punch card codes for complete plot and detailed disease data for each tree on permanent sample plots has been developed by the California Station. Numerical codes have been devised for the various diseases and intensities as well as pertinent tree data for individual trees. The system not only saves much time and simplifies computations and analysis, but also saves considerable field time in recording data. (Sample forms follow this page).

4. Convenient tree tags for permanent plots

Submitted by: J. W. Kimmey

Address: California Forest & Range Experiment Station, Berkeley, California

Techniques: Tree tags made of 20 gauge aluminum and the exact diameter of a quarter dollar may be used in a belt coin dispenser with quarter size tubes.. We ordered the tags stamp numbered consecutively 1 to 150 and in paper rolls for ease in loading dispensers. Tags have a drilled hole at the top large enough to admit a 2-1/2 inch aluminum nail. The nails and tags are permanent and being soft eliminate future damage to saws.

5. Determining when trees died.

Submitted by: G. P. Thomas

Address: Forest Biology Laboratory, Victoria, British Columbia

Technique: In the course of investigating some disease problems it is imperative to know the exact year of death that can be assigned to individual dead trees. This problem has been circumvented in some instances by killing trees for subsequent analysis and in others by marking sickly trees and waiting for

CF&RES-341
Rev. 1-24-57
FDR

PERMANENT MORTALITY AND DISEASE SURVEY PLOT

Subregion	X ____	Site	X ____	T ____ R ____ S ____ M ____
County	XX ____	Elevation	XX ____	Site Tree: Sp. ___ Dbh. ___ Ht. ___ Age ___
Ownership	XX ____	Aspect	X ____	Number of Trees on Plot ____
National Forest	XX ____	Slope	X ____	Data by: ____
Plot No.	XXX ____	Type	XX ____	Notes by: ____
Plot Size	X ____	Stand Size Class	X ____	Date ____
Measurement No.	X ____	Stand Treatment	X ____	
Year	XX ____	Density	XX ____	X indicates number of digits in item code.

TREE DATA	PATHOLOGICAL DATA

CF&RES-341 Cont.
Rev. 1-24-57
FDR

PERMANENT MORTALITY AND DISEASE SURVEY PLOT

Subregion	X ____	Measurement No.	X ____	Plot Name	____
Plot No.	XXX ____	Year	XX ____	Data by:	____
Plot Size	X ____	Date	____	Notes by:	____

TREE DATA							PATHOLOGICAL DATA																						
							Injury		Bole Wounds		Abnormal Growth			Heart Rot		Dwarf Mistl.		Leaf Dis.		Rust		Root Dis.		Physl Dis.		True Mistl.		Cause of Death	
Tree Number	Species	1/10 Inch Dbh.	Dunn Tree Class	Keen Tree Class	Risk Class	Merch. Class	Kind	Intensity	Kind	Intensity	Kind	Intensity	% Cull, Bd. Ft.	Kind	Intensity	Kind	Intensity	Kind	Intensity	Kind	Intensity	Kind	Intensity	Kind	Intensity	Kind	Intensity	Initial	Final
XXX	XX	XXXX	X	XX	X	X	XX	XX	XX	XX	XX	XX	XX	X	X	X	X	X	X	X	X	X	X	X	X	X	X	XX	XX

CF&RES-342(1)
1/24/57
FDR

PERMANENT MORTALITY AND DISEASE SURVEY PLOT
SEEDLING AND SAPLING SUBPLOT

Subregion X ____
Plot No. XXX ____
Plot Size X ____

Measurement No. X ____
Year XX ____
Date ____

Plot Name ____
Data by: ____
Notes by: ____

No. of Trees	Species	Size Class	Injury		Disease		Tally	Notes
			Kind	Intensity	Kind	Intensity		

CF&RES-342(2)
1/24/57
FDR

Plot Established by (Agency) ____ Date Established ____

Instructions for Reaching Plot (Give road directions from nearest town) ____

Description of Plot Reference Point ____ them to die or by accepting an approximate year of death as being satisfactory. A technique, devised by A. W. Ghent (1, 2) in eastern Canada and used by him in work with aspen, spruce, balsam fir, and sugar maple, appears to be admirably adapted to solving this chronic problem in forest pathology. The system was used with complete satisfaction in British Columbia in recent work with decay in dead Douglas fir.

The technique requires that thin discs be cut from the bole of a number of living trees of the species under investigation in reasonable proximity to the study area. Year dates and widths are assigned to all rings as they occur along three axes of each disc. An ocular micrometer attached to a dissecting binocular microscope provides a satisfactory means of measuring ring widths. The measurements obtained are averaged for each ring year and a master graph of the ring pattern of living trees is prepared by plotting ring width against ring year, commencing with the outer ring at the extreme right of the graph. Separate graphs for each dead tree required in the study are prepared in the same manner. By aligning the graphs of dead trees with the master graph of living trees the position of obvious best fit is readily obtained. Thus, the last year of growth for a dead tree can be read directly from the master graph as being the year opposite the dead tree's outer ring.

Trees of any crown class can be sampled and discs can be taken at any point of the bole without impairing the accuracy of the system. In general, a master graph might be expected to apply to trees located anywhere within the same climatic region.

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2. Ghent, A. W. The treatment of decayed wood from dead trembling aspen trees for growth-ring analysis. For. Chron., 30(3): 280-283. 1954.

A LABORATORY METHOD FOR THE STUDY OF DECAY RESISTANCE IN FAST- AND SLOW-GROWN SUBALPINE SPRUCE UNDER UNIFORM MOISTURE CONDITIONS

by D.E. Etheridge

To investigate factors that might be responsible for the different rates of decay found in fast- and slow-growing spruce trees in Alberta, laboratory experiments were carried out to study the effect of specific gravity, ring-frequency, and chemical properties of wood on the amount of decay caused by <u>Coniophora puteana</u> (Schum ex Fr.) Karst. For a statistical assessment of these factors the experimental design was to hold the moisture content constant at a uniform level, and to minimize any effect which might result from inoculating, oven-drying, or sterilizing the test blocks. It was found that the standard techniques usually employed in experimental work on the decay of timber, were for the most part, inadequate. Therefore, it was necessary to modify these methods or devise new ones which would achieve the object of the experiment. A brief description of the techniques that were finally adopted for this work are reported as some of these might have general application.

Test-blocks

Samples of heartwood approximately 1 x 1 x 6-7 inches were cut from fast- and slow-grown trees to obtain test-blocks having different ring-frequencies and specific gravities and these were maintained at room temperature and humidity until required for the experiments. To provide adequate replication for statistical treatment of the results, nine blocks of wood measuring approximately 1 x 1 x 3/4 inches were sawn in sequence from each sample. Except an end piece which was selected for determining the moisture content of the sample, holes were drilled half-way through one side of each block to take the water amendment and a plug of wood inoculum as shown in Figs. 1 and 2. The nine blocks were then numbered for identification later and weighed. The oven-dry weight of each of the drilled blocks was calculated, assuming that they contained the same moisture as the selected blocks which had been oven-dried at 105°C. for 24 hours.

The blocks used for the moisture determinations were also used to determine the specific gravity and the ring-frequency of the group. The specific gravity was calculated from the oven-dry weight and the volume of the wood at a moisture content above the fibre saturation point, i. e., the green volume. The blocks were brought to the green volume by soaking in water for 24 hours, and then immersing them in mercury in a graduated cylinder; the volume of the blocks was estimated to be the nearest ml. To eliminate some of the differences in the moisture content due to differences in specific gravity, for comparative purposes, the moisture content was expressed as the percentage of the cell-cavity which contained water, i.e., percentage of saturation. These determinations were calculated according to a formula given by Brown, Panshin and Forsaith[2], which uses the specific gravity based on the volume of wood when the moisture content is above the fibre saturation point:

$$\text{Percentage of saturation} = \frac{(M - 28)\ SG}{1 - 0.93\ SG}$$

where, M = conventional moisture content

SG = the specific gravity of the wood based on the green volume assuming the fibre saturation point to be at 28 per cent of the oven dry weight, and the specific gravity of the dry wood substance to be 1.46.

Inoculum

The best method of inoculating the test-blocks was found by preparing discs (about 22 mm. in diam.) or plugs (about 6 mm. in diam.) of wood as shown in Figs. 1 and 2. These were placed in 250 ml. flasks on a layer of spruce sawdust (about 3 grams), to which was added 5 per cent of an accelerator recommended by Badcock[1]. Water was added at the rate of 170 per cent of the oven-dry weight of the sawdust. After sterilization at 15 lbs./sq. in. for 30 minutes, the flasks were inoculated with plugs of agar taken from a 2 to 3 week-old plate culture of the appropriate fungus. The pieces of wood were then incubated with the fungus for 3 months; water was added to the cultures periodically to maintain the moisture content of the wood at about 70 to 80 per cent (o.d.w.)

Decay cultures

Wide-mouthed jars 5.5 cm. x 5.5 cm. with aluminium screw-top lids were used as shown in Fig. 3. The glass jars were thoroughly washed, rinsed in distilled water, and then sterilized in an oven for 2 hours at 160°C. The wood blocks were sterilized with propylene oxide gas in the way described by Hansen and Snyder[3]. The blocks were placed in a large desiccator on a perforated tray over propylene oxide gas which was introduced at the rate of 1 ml. per litre of the container. The blocks were left over-night and the gas was then removed with a suction pump, and the vessel flushed a number of times with filtered air. The treated blocks were transferred to sterile culture jars. This treatment had a negligible effect on the moisture content of the blocks.

Adjusting the moisture content of the blocks

After sterilizing the blocks and before adding the inoculum, the required moisture content was obtained by adding the required amount of sterile distilled water to the holes drilled in the sides of each block from a hypodermic syringe calibrated to 0.1 ml. The amount of water added took into account the equilibrium moisture content and the specific gravity of the wood. After making this initial adjustment to the moisture content, the blocks were inoculated withthe appropriate fungus, the lids loosely screwed down, and the jars immediately placed in a saturated atmosphere in humidity chambers as shown in Fig. 3. To maintain a constant and uniform moisture level, adjustments were made to the moisture content of the blocks during incubation.

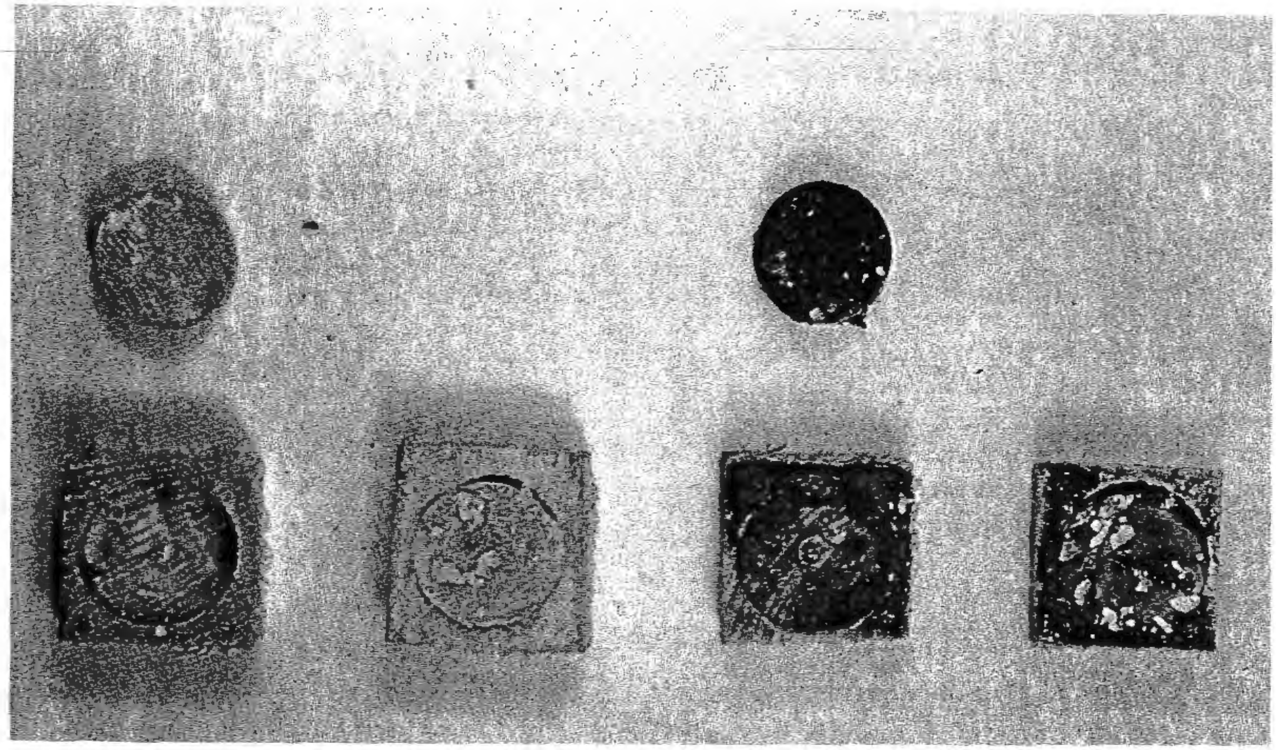

Fig. 1. Test blocks, cavity type ($1 \times 1 \times \frac{3}{4}$ ins.), infected with pure cultures of Stereum sanguinolentum (white mycelium) and Coniophora puteana (black mycelium) showing the method of inoculation.

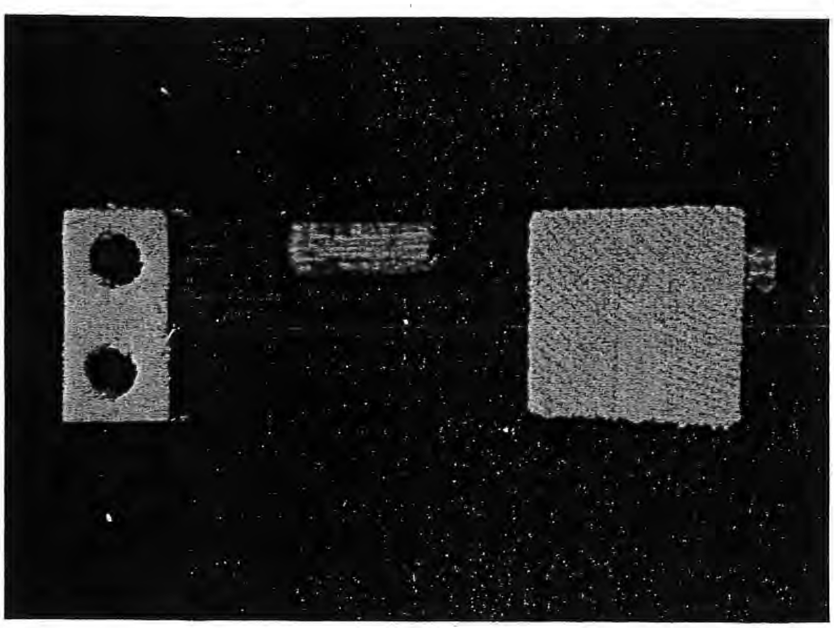

Fig. 2. Test blocks, socket type ($1 \times 1 \times \frac{3}{4}$ ins.), used in the moisture - decay experiments showing the method of inoculation.

About midway through the incubation period the blocks were removed from the jars in a room exposed to ultra violet light from a germicidal lamp for one hour and, after removing the disc of inoculum from the blocks they were weighed aseptically to the nearest .01g. on a Joly spring balance, the pan of which was contained in an inoculating-hood. The water content of the blocks was then calculated; if it were excessive, the blocks were allowed to lose water by keeping them on the laboratory bench for a few days; if it were too low, the necessary amount of water was added from a hypodermic syringe. Little contamination followed this procedure. The decay activity was measured as the loss of weight during incubation as a percentage of the original oven-dry weight.

The chief advantages of this procedure for comparative studies of the decay of timber may be listed as follows:

1. By oven-drying only one block from each sample for moisture determinations, and by surface sterilizing with a fumigant such as propylene oxide, tests can be carried out with wood that has not been pre-heated.

2. By inoculating the test-blocks with pieces of infected wood, instead of the usual practice of placing test-blocks on the surface of actively growing cultures (of the test-fungus grown on nutrient media, the chances of introducing certain growth-promoting factors with the inoculum are reduced. Moreover, the mode of infection that possibly occurs in nature is simulated by the use of wood inoculum.

3. By expressing the moisture content as a percentage of the cell cavity occupied by water, differences in the moisture content of the wood resulting from differences in the size of the cells, are eliminated. Using the conventional method of expressing moisture content, i.e., oven-dry weight basis, the proportion of the cell that is occupied by water varies with the specific gravity of the wood.

4. Finally, the procedure makes provision for adjusting the moisture content of the test blocks during the period of incubation. This reduces the considerable variation that frequently occurs between the initial and final moisture content values of the test-blocks.

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2. Brown, H.P., Panshin, A.J., and Forsaith, C.C. (1952) Textbook of wood technology, Vol. 11. 1st Ed. McGraw-Hill Book Co., Inc. N.Y.

3. Hansen, H.W. and Snyder, W.C. (1947) Gaseous sterilization of biological materials for use as culture media. Phytopath. 37: 369-371.

APPENDIX IV

PUBLICATIONS

1a. Davidson, R. W., and Cash, E. K. A *Cenangium* associated with sooty-bark canker of aspen. Phytopathology 46: 34-36, illus. 1956. (   )

1b. ______________, and Hinds, T. E. *Hypoxylon* canker of aspen in Colorado. Plant Disease Reporter 40: 157-158, illus., 1956. (   )

2. Gill, L. S., and Andrews, S. R. Decay of ponderosa pine slash in the Southwest. Research Note 19, 2 pp. 1956. (   )

3. Gruenfeld, J. J., Ernest Wright, and W. K. Coulter. Operation Counterattack. The Timberman LVII: 12. 1956. (   )

4. Hawkins, E. F. Reference collections of pure cultures of wood-destroying and other fungi. Can. Dept. Agr., For. Biol. Div., Victoria, B. C. Unpbl. rept. 1956. (53-A-4).

5a. Hawksworth, F. G. Notes on the host relationships of *Arceuthobium americanum* and *A. vaginatum* f. *cryptopodum*. Plant Disease Reporter 40: 252. 1956. (   )

5b. ______________. Note on the susceptibility of Indian paint-brush to *Cronartium filamentosum*. Plant Disease Reporter 40: 581-582. 1956. (   )

5c. ______________. Upper altitudinal limits of lodgepole pine dwarfmistletoe in the central Rocky Mountains. Phytopathology 46: 561-562, illus., 1956. (   )

6. ______________ and Lusher, A. A. Dwarfmistletoe survey and control on the Mescalero-Apache Reservation, New Mexico. Jour. Forestry 54: 384-390. illus., 1956. (   )

7a. Kimmey, James W. Cull factors for Sitka spruce, western hemlock, and western redcedar in Southeast Alaska. Station Paper No. 6, Alaska Forest Research Center, U.S.F.S., Juneau, 31 pp., illus., 1956. (53-G-8).

7b. ______________. Forest disease conditions in California, 1956. (Mimeographed report) (55-A-1)

8. ______________ and John A. Stevenson. A forest disease survey of Alaska. Submitted to Forest Science for publication (53-A-2).

9. Leaphart, Charles D. Physiological studies of some fungi associated with pole blight of western white pine. Mycologia 48(1): 25-40, 1956. (53-I-1)

10. Mielke, James L. The rust fungus (Cronartium stalactiforme) in lodgepole pine. Jour. Forestry. 54: 518-521, illus. 1956. ( )

10a. ______________. A needle cast of lodgepole pine caused by the fungus Hypodermella concolor. Research Note 27, 3 pp., 1956. ( )

11. Molnar, A. C. Pullularia pullulans associated with a flagging disease of western white pine. Can. Dept. Agr. Forest Biol. Div., Victoria, B. C. Unpbl. Rept. 1956. ( )

12. Wright, Ernest and Kenneth H. Wright. Deterioration of beetle-killed Douglas fir in Oregon and Washington. Pac. N. W. Forest & Range Expt. Station, Res. Bull. 10. 1954. ( )

13. Wright, Ernest, W. K. Coulter, and J. J. Gruenfeld. Deterioration of beetle-killed Pacific silver fir. Jour. Forestry 54:4: 322-325. 1956. ( )

14. Wright, Ernest, and Leo A. Isaac. Decay following logging injury to western hemlock, Sitka spruce, and true firs. USDA Tech. Bull. 1148. 1956. 34 pp., illus.

15. California Forest Pest Control Action Council. Forest pest conditions in California, 1955. Calif. State Div. Forestry, Sacramento, 21 pp., illus. 1956 (55-A-1).

Appendix V

MINUTES - BUSINESS MEETING

FOURTH WESTERN INTERNATIONAL FOREST DISEASE WORK CONFERENCE

(Held at El Paso, Texas, November 27-30, 1956)

The business meeting of the Fourth Western International Forest Disease Work Conference was opened at 1:30 p.m., November 30, 1956, in the Hilton Hotel, El Paso, Texas, Chairman Lake S. Gill presiding.

The minutes of the last meeting, in Spokane, Washington, were read and approved.

A report of the expenses for the meeting was read by S. R. Andrews and Kimmey moved the report be accepted as read and revised by Andrews. This was seconded by Alex Molnar. Carried.

A report by the Memorial Committee on gifts in memory of Don Buckland was presented and accepted as sent in by Chairman R. E. Foster.

Report of the Chairman of the D. C. Buckland Memorial Committee:

This committee was established by L. S. Gill in April 1956, under the chairmanship of R. E. Foster. Terms of reference were indicated as follows: To determine the most appropriate course of action for the Western International Forest Disease Work Conference in regard to the establishment of a memorial award to the memory of the late Dr. D. C. Buckland and to take appropriate steps to bring this course of action to fulfilment.

Committee members subsequently appointed were: J. L. Bedwell, J. E. Bier, R. J. Bourchier, C. D. Leaphart, L. F. Roth, and G. P. Thomas.

Following careful appraisal of various alternatives by this committee it was concluded that it would be most appropriate for the Work Conference to donate a suitably inscribed memorial book or books to the library of the University of British Columbia. This proposal was placed before the membership on September 18 and in due course contributions totaling $71.10 in Canadian funds received. This sum has been placed in the care of J. E. Bier who has agreed to assume responsibility for the selection of suitable texts. No further action can be reported at this time.

November 21, 1956. /s/ R. E. Foster

There was some discussion of the report by the committee on revision of the proceedings (Leaphart chairman).

1. Format: Kimmey states that one heading on page 97 should be changed in that publications listed with projects were not listed in Appendix 4. Might change heading or try to list all publications in one main list, or change to "Publications since last proceedings".

2. Should complete papers be included-? Members present seemed to strongly favor complete papers.

3. Coding System:

   Is coding system too complicated-? There was some discussion on this question and Andrews, who was a member of the committee, made a statement in reply, and that the system used seemed to consolidate the thinking of the committee..

   Perhaps most of the members present had not taken time to look over the new proceedings for a very constructive discussion (Secretary). Seems to be no information on 7 groups and why were papers in 1955 Proceedings not coded.

4. Publication status:

   Should the Proceedings continue to carry the "Not For Publication" statement? Consensus of those present favored leaving this statement on.

5. Summaries:

   Chairman of sessions at this year's meetings seemed to find it difficult to work up summaries.

6. Cost and Summary:

   It was suggested that the present committee try to have each author mimeograph (at least prepare stencil for) his own paper. Restrict sizes of paper used and kind and size of type. That these papers be assembled by the Committee.

Motion: That the future proceedings follow the format of 1955. (This constitutes approval of the format and coding system as set up by Proceedings committee), and summaries be left to the discretion of the moderators, that it not be issued as a publication, method of getting out Proceedings be left to the present committee. Made by H. Offord, seconded by T. Childs, Carried.

Report of the Committee on Standardization of the Proceedings for the W.I.F.D.W.C.

It was decided at the 1955 meeting of the W.I.F.D.W.C. that a committee should be formed to standardize the Proceedings of our annual meetings. I was selected to chairman this group. The following men were chosen and offered to help me: Stewart Andrews, Paul Lightle, and Phil Thomas. To these men, we owe a great deal of appreciation for their industry and effort in organizing the format and procedures for recording the proceedings of our conference. I take this opportunity to thank them for their cooperation and a job well done. I wish to express my thanks also to Bob Bourchier, Toby Childs, and again to Phil Thomas for helping me to compile and organize the sections for which they served as moderators in last year's program, and also for providing the completed stencils of their portion of the Proceedings.

The combined effort of these men and others, to whom I am also grateful, produced the Proceedings that were distributed to the membership early this month. Now that you have had an opportunity to review this issue, several important questions must be decided up.

1. Is the proposed format acceptable from the front to the back? Special attention should be devoted to Appendixes I through V. Eleven categories have been provided in Appendix I; and, although they do not cover all subjects adequately, I do not think it advisable to enlarge upon them. For instance, surveys and resistance studies that are related to a specific disease, such as blister rust, should fall under the category designated for rusts and cankers. We have made a sincere attempt to bring Appendix IV up to date. All publications have been coded to projects reported on during the last three years. You should all code your new projects, terminated projects, and publications at the time they are submitted for inclusion in future proceedings, provided this present coding procedure is acceptable to the membership.

2. Should the Proceedings carry a notice, such as "Not for Publication" - as was done on the 1955 issue. There are only two alternatives: one, we limit distribution and make a statement to the effect that material reported therein should be quoted or referred to in publications only on the permission of the author; or two, we provide for a general and larger distribution so that the material constitutes a bonafide publication. A decision here will dictate the type of, and preparation of papers presented at future meetings. Certainly the former appears much more simple to follow but one must also place his faith in professional ethics. In the former, we can maintain the informal approach

to our respective problems that may be lost in more formal papers. In any case, it appears that written contributions are essential to maintain the continuity of the meetings. If the latter alternative is followed, considerably more attention must be given to financing the publication of the Proceedings - a point that is discussed later.

3. Should the moderators prepare a summary of the papers and discussion for their respective panels? I do not believe that we should include verbatim records of discussions but I do feel that a summary would lend a great deal of continuity and value to each panel presentation.

4. How should the Proceedings be financed? If the 1955 issue had not been a collection of contributed time and effort, but had been prepared by a commercial agency, I estimated that it would have cost us $600 + 25 for preparation and proof-reading stencils, mimeographing, assembling, materials, and mailing. Nine-tenths of this could be attributed to preparing and proof-reading the stencils.

I think it is well for you to keep this thought in mind when you consider any necessary revisions of the 1955 Proceedings. Not long ago Lake Gill write me after having received a copy, that he had forgotten to some extent how much good information and thinking had come out of our Conferences. It is up to us to record this information in the best possible way.

/s/ Charles D. Leaphart, Chairman

The status of the two technical committees (Decay Standards and Sample Plots) came up. A. E. Molnar, chairman of the "Plot Standardization Committee" brought out that this group (composed of Chairman A. E. Molnar, T. W. Childs, F. G. Hawksworth, D. P. Graham, and J. Kimmey) had not had a chance to come up with a very complete report based on concerted effort of the committee.

The Report of the Committee on Decay Standards follows:

A motion by W. Wagener, seconded by J. L. Mielke, during the 1955 annual meeting of the Western International Forest Disease Work Conference established a committee under R. E. Foster to consider the definition of standards of measurement data in decay studies.

Subsequently, this committee was expanded to include J. E. Bier, J. E. Browne, T. W. Childs, L. S. Gill, J. W. Kimmey, V. J. Nordin, L. F. Roth, E. Wright. The activities of this committee may be summarized as follows: A preliminary set of standards was drafted, critically reviewed and revised. Several additions and changes to the revised code have been recommended. These suggestions are currently under review. It is anticipated that a final report will be available for submission to the general membership early in 1957.

November 21, 1956. /s/ R. E. Foster

Motion: By Harold Offord and Keith Shea. That the two technical committees be continued until such time as their work is concluded to the satisfaction of the conference, with no implication of criticism involved. Motion carried.

Upon completion of this evaluation - study such alternate proposals as are forthcoming and submit to members for their consideration. Motion carried.

In the discussion there seemed to be a general feeling that there should be no backing down from holding meetings of the Work Conference regardless of Administrative attitude concerning official approval to attend.

Motion: By Childs - that attending members go on record as favoring meetings at intervals of not less than two years, unless circumstance demands more frequent meetings. Seconded by Offord.

Motion failed to carry.

Officers:

1. General Chairman: Kimmey nominated Phil Thomas for next year's Chairman. Thomas was elected by unanimous vote of the members.

2. Secretary: Toby Childs was elected by a unanimous vote.

Chairman Gill suggested that the committee on incoming policy be made by the new Chairman.

Motion: T. Childs - a vote of thanks to the El Paso Chamber of Commerce, and especially to G. P. Hunt, for their very helpful cooperation. Motion Carried.

Gill expressed appreciation for the excellent help and cooperation he received from the committee, particularly the program committee, and the panel members were conscientious in making the meeting a success.

Business session adjourned.