Proceedings of the Tenth Western International Forest Disease Work Conference
Victoria, Alberta October 1962

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SPECIAL REPORT

FORWARD

The tenth Western International Forest Disease Work Conference was held October 15-19, 1962 in Victoria, where, in 1953, the first Conference assembled. Sixty members and guests registered. On Monday registration was conducted in the Strathcona Hotel, where a majority of those participating made their headquarters. The Meetings, held in the Customs Building, were opened with welcomes from Richard Parmeter, Conference Chairman and R. E. Foster, Officer in Charge of Forest Pathology Investigations at the Victoria Laboratory.

Particpants in the conference were cordially invited to visit the laboratories and offices of the Forest Pathologists stationed in the Federal Bulding at Victoria. A most interesting array of displays and demonstrations were competently explained by our hosts. Indeed, most visitors became so engrossed in "talking shop" in the first laboratory they entered that the evening proved too short to canvass everything.

The field trip included visits to the B. C. Forest Service Nursery at Duncan (damping off of coniferous seedlings, soil sterilization procedures, etc.) and the Cowichan Lake Forest Experiment Station. The British Columbia Forest Service was our host organization for the day and made arrangements for lunch and coffee breaks. Seventy-eight members, guests and wives attended the banquet on October 17th, held at the Royal Colwood Golf Club. Phil Thomas, last year's winner of the Wifdwc award entertained the group with an expurgated version of the epic: "The Story of Rosellinia and Boletus" (The complete, unexpurgated version has been included in these proceedings.) With obvious reluctance, Phil relinquished the trophy to his successor, Toby Childs. For the first time an award was made to an associate "member" on the distaff side, Mrs. James W. Kimmey. Mr. Thomas Wright, Dean of the School of Forestry at the University of British Columbia presented a thought-provoking discussion of the Future of Forestry in the Province of British Columbia.

The tenth W. I. F. D. W. C. was adjourned the afternoon of October 19, 1962. The last item of business was the acceptance of the by no means "off the cuff" invitation of Lowell J. Farmer for next year's conference to assemble at Jackson Hole, Wyoming.

Executive Committee

J. R. Parmeter, Chairman
C. G. Shaw, Secretary-Treasurer

Program Committee

K. R. Shea, Chairman
R. G. McMinn
J. W. Roff

Local Arrangements Committee

R. G. McMinn, Coordinator
Pathology Section, Victoria Laboratory

OPENING REMARKS

Chairman J. R. Parmeter

This is the decennial meeting of the Western International Forest Disease Work Conference. Since its origin, ten years ago, the Conference has become one of the most valuable and looked-forward-to meetings of the year. I think you'll all agree that the success of W.I.F.D.W.C. is due in no small part to the informal atmoshere surrounding our discussions and to the energetic participation of all members.

For our tenth meeting, your program committee, Keith Shea, Jack Roff, and Bob McMinn has provided several interesting topics for consideration. Your local arrangements comittee, Bob McMinn and the entire Victoria staff, has provided the necessary surroundings and accomodations. I know that you will provide the discussion.

There are any number of comments a chairman might make to open the meeting, but it is customary for some person of high position in the meeting locale to extend a welcome and to extoll the virtues of his particular environment. So without further ado, I'd like to introduce Ray Foster.

ADDRESS OF WELCOME

R. E. Foster

Mr. Chairman, Members, and Guests of the Tenth Western International Forest Disease Work Conference:
I have the pleasure of welcoming you to Canada's most beautiful city and to the major center of research in forest pathology in North America. Admittedly, these observations may contain some element of biased personal opinion, but I am confident that any doubts you may have in either regard will be dispelled long before you leave.

This is our 10th anniversary, and I would be remiss in my capacity as Conference Historian (an honour bestowed upon me in my absence from the last annual meeting) if I did not offer at least one comment bearing on this event.

I am very pleased to note the presence of Senor Riquelme Inda. Although Sr. Riquelme has been in correspondence with us for several years and has forwarded papers for our Proceedings, this is the first time that we have had the privilege of welcoming him to Canada and it is evident that our meeting will take on further international flavour, and benefit from this wider association.

This is not the first time we have met in Victoria -- our very first Conference was held here in 1953. The primary objective then, and now, was to bring together those engaged in surveys and research in forest pathology in western North America to promote the exchange of information on forest diseases of mutual interest and concern.

A review of the subject matter contained in the Proceedings of our nine previous Conferences verifies that this primary objective has remained in sharp focus. In my opinion it is this sense of purpose which has enabled us to retain our status as a Work Conference. Admittedly, we have entertained other matters over the years, but these excursions have broadened our understanding of regional problems and have not impeded our progress or diverted us from our primary goal. If we can retain this sense of direction I am confident that our next decade will be marked with progress equal to that achieved to date.

We have come a long way during the past 10 years but we have a great deal left to do, and it is evident that there will be need for meetings of this nature well into the future. We recognize problems today which we were completely unaware of in 1953; and in respect to problems included in our first agenda that are still with us, new concepts and techniques have developed which warrant our consideration. In this connection it may be of interest to note that a number of suggestions for future programs were made last year, and printed in our Ninth Proceedings. I have examined this list of some 23 suggestions, but have been unable to find any that have been incorporated in our present agenda. Despite this, I am confident that there is much on the program to hold your interest and stimulate your comment.

I am very pleased to welcome you to the City of Victoria during its Centennial year, and on behalf of the Victoria Laboratory to the Work Conference during its tenth birthday. I extend to you the facilities of our laboratory during your visit and I wish you success in your deliberations.

Thank you.

GREETINGS FROM MEXICO

Julio Inda Riquelme

Ladies and Gentlemen:

First of all I want to thank the Board of Directors of this Conference for the opportunity they have given me to convey the greetings of the Secretary of Agriculture of the Republic of Mexico, Mr. Julian Rodriguez Adame, and also of Dr. Enrique Beltran, Sub-Secretary of Forestry Resources, who have given me their representation to attend this meeting and to wish you a most successful Conference.

At the same time, allow me, in behalf of the Sociedad Forestal Mexicana and as Life President, to give you a most cordial salutation and very best wishes for the success of the working sessions, which without any doubt will be a tremendous value.

Our government and the Society I represent wish to continue close relationships and the exchange of works and research on plagues and diseases of trees with you. Such cooperation undoubtedly will benefit all three countries.

We hope that in the near future Mexico can be honored by this conference holding its meetings in one of our many beautiful states — giving us the opportunity to express our sincere and real friendship.

I thank you.

A REVIEW OF SOME HIGHLIGHTS IN RESEARCH ON ECTOTROPHIC MYCORRHIZAE

J. C. Hopkins

Summary. The term mycorrhiza is a loose one with a primarily morphological basis. It implies a similarity which may or may not extend beyond morphology and tends to obscure the fact that it involves many combinations of host and fungal species, each of which may be physiologically distinct and should be distinguished when mycorrhizal data are reported. It is also suggested that the term symbiosis might be restricted to those cases where an investigation carried out over a long period has demonstrated that both associates either grow more rapidly, or produce reproductive structures more abundantly, when in mycorrhizal association than when separate.

Several main lines of research on ectotrophic mycorrhizae may be distinguished. One line is concerned with the identity of the fungal associates. Over 50 species of basidiomycetes have been proved to form ectotrophic mycorrhizae and a few studies have shown that ecotypic strains of the fungi may occur. Another favoured approach has shown conclusively that enhanced growth of the host frequently results from mycorrhizal formation and several explanations for this effect have been proposed. The most likely of these explanations suggest that mycorrhizae are more efficient at salt absorption than non-mycorrhizal roots, and may also assist by utilization of organic nitrogen. Other studies have been concerned with the variation in the extent of mycorrhizal development which occurs in different soils and under different light intensities. Explanatory hypotheses, still untested, have been proposed for this too, linking the variation with the mineral content of the soil, and, or, the carbohydrate status of the roots, although in some areas the distribution of mycorrhizal fungi may be a prime factor. Another approach, still undeveloped, concerns the activities of the fungal associates in soil, attached and unattached to the host. Other studies have dealt with the processes involved in the interaction of fungus and host, including morphogenesis and the physiology of salt absorption.

"TRANSLOCATION RELATIONSHIPS INVOLVING ARCEUTHOBIUM and PHORADENDRON SPECIES"

R. J. Hull and O. A. Leonard

The material contained in Appendix VII - "Committee Report On Status and Needs of Research on Dwarf Mistletoes" covers the main research aspects that were presented. The reader is referred to Appendix VII.

The project is still quite active. Writing of formal paper or papers will be deferred until more research has been conducted.

TISSUE SAPROPHYTES AND THE POSSIBILITY OF BIOLOGICAL CONTROL OF SOME TREE DISEASES

John E. Bier[1]

In presenting the results of this research grateful acknowledgment is given to the MacMillan, Bloedel and Powell River Co. Ltd., and the National Research Council of Canada for the provision of financial grants in support of the studies. Should the results prove of value to Forestry, considerable credit would be due to these agencies for their continued interest and support.

It is felt that there is an urgent need in forest research to establish "Clinical Indices" within trees that will enable the Foresters to classify the degree of health, vigor, and disease vulnerability in different stands. It is insufficient to relate the incidence or severity of a disease with abstract factors such as soil and climate since the results of such analyses may have limited application and lead to a number of multiple correlations that are difficult to assess or define. At this point a lesson may be learned from the practice of Medicine. Initially the Doctor does not make detailed analyses of the patient's nutrition, nor the atmospheric environment in which he or she may live. First diagnosis consists of clinical tests such as the patient's pulse, blood pressure, etc. The state of health or disease indicated by these tests may lead to the factors of malnutrition, sudden chilling, etc. It is believed that clinical tests, easy to perform, may be taken in trees which will indicate their level of health and susceptibility or resistance to diseases. Furthermore, such clinical tests may establish whether the disease under investigation had developed primarily because of some nutritional or climatic disturbance.

The results of studies (1) on the moisture content of functional, living cells in the young bark and foliage of trees have demonstrated excellent correlations between the moisture content of the cells and the level of tree vigor based upon factors such as rooting potential and vulnerability to a number of canker diseases. Therefore, the moisture level of these tissues may serve as one of many useful "Clinical Indices" that may be discovered in the future. High moisture content in functional cells has indicated healthy and disease resistant tissues that were able to absorb and retain more moisture during periods of stress.

[1]Professor, Forest Pathology, University of British Columbia

There is a difference in the physiology of trees and man that frequently is not fully appreciated. The physiological processes in a healthy man are similar during all months of the year. Trees, on the other hand, experience two distinctly different periods of physiological activity each year. During growth which may last three or four months the tree is very active physiologically and capable of preventing infection by the rapid healing of wounds, production of resin, etc. During dormancy which may last seven or eight months of the year the tree is inactive and unable to perform many of the phenomena which will assist in preventing disease attack. If we wish to establish which are the most vigorous trees or stands and least susceptible to many diseases perhaps the clinical tests should be made during the dormant period rather than when the trees are in full growth. Certainly, in all tree species investigated the moisture content of the functional cells in bark and foliage has been appreciably less during the dormant period.

During the investigations on bark and leaf moisture (2 and 3) it became evident that the healthy tissues of trees were colonized by numerous harmless saprophytes (fungi and bacteria). Indeed, healthy foliage and bark should not be considered as entities but rather as complex biological communities. Furthermore, a number of the saprophytes on healthy tissues were proven to be very efficient individually or collectively in preventing infection by different disease-causing organisms. These saprophytes occurred externally and internally in healthy trees and provided the maximum degree of protection against disease attack when the tissues contained an abundant supply of water. A moisture differential was demonstrated for the optimum development of the saprophytes and pathogens on living trees. When the moisture content of the tree tissues was lowered too far the saprophytes became ineffective in preventing infection.

However, the degree of coverage of forest trees by the saprophytes is accidental, the organisms reaching the tissues by factors such as wind and rain. Some trees or parts of trees (e.g. new growth) may be colonized by fewer saprophytes than others, and contain less than the minimum necessary to perform this type of resistance. Such being the case would it be possible to apply dips or sprays containing large numbers of the saprophytes and achieve a degree of biological control of tree diseases? Furthermore, applying more saprophytes to supplement those provided by Nature may lead to lowering the threshold level of moisture for infection, which would enable the trees to withstand greater drought and adversity and remain free from disease attack.

The results of laboratory experiments (2 and 3) have shown that solutions containing a sufficient number of saprophytes to control a number of tree diseases may be prepared very easily by placing one gram of healthy leaf or bark tissue into a flask containing 75 c.c. of sterile, distilled water. The flasks are placed on a slow speed shaker for a period of approximately five days at room temperature. The leaf or bark tissues provide the nutrition and the shaker the aeration for the growth and multiplication of the saprophytes. Applications of these solutions to inoculated trees in the laboratory have proven effective in controlling the diseases caused by a number of bark canker and decay fungi, and one leaf rust fungus. These pathogens are representative of a broad range in types of tree diseases.

Applications of the solutions containing the saprophytes would appear to result in a higher level of tree vigor in addition to preventing infection. Preliminary experiments (4) have indicated that the production of secondary roots was increased appreciably when the basal ends of cuttings were placed in contact with the test solutions. Therefore, the solutions may have served a dual purpose, and were proven not to injure the newly-developing roots and shoots. It is well to remember that the application of toxic chemicals to trees will result in the destruction of the beneficial saprophytes in addition to the disease-causing organisms.

The procedures outlined may prove to be an inexpensive method of supplementing nature to achieve the biological control of some tree diseases. The results of field trials are necessary to assess the value of spray treatments.

The following statement was made in the summary of a paper (5) presented at the Annual Meetings of the C.I.F. in Saskatoon in 1955: "Sound recommendations for prevention or control of tree diseases will not be available until a better knowledge is obtained on the basic factors influencing the host-parasite relationships within a forest". If any value is achieved from this research it will be due to a strict adherance to this principle.

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AN ASSESSMENT OF THE SIGNIFICANCE OF DISEASE IN DOUGLAS FIR PLANTATIONS

R.E. Foster, Victoria, B.C.

(Note: A revised manuscript based on the paper presented at the 10th Annual Meeting is under preparation and will be submitted to the Forestry Chronicle for publication during 1963).

Abstract

Mortality is a normal phase of stand development and is detrimental only if it reduces the final yield, creates undesirable stand openings, or eliminates a tree suitable for utilization during an intermediate harvest. The significance of root rot and frost damage in 16 to 18 year old Douglas Fir plantations are examined in this context. No significance could be attached to frost-damaged trees, even in areas with 30% of the trees affected, as no openings of sufficient size to support a crop tree would have been created even had all affected trees died. On the same reasoning, very little significance was atttached to root rot. Although root rot occurred in an aggregated pattern and as many as 30 per cent of the trees were infected in one area, most of the focal centers

consisted of only one or two trees and most of the openings created were of negligible size. Further study will be required to determine if any future increase in root rot arises more from the development of new focal centers than from the enlargement of existing foci; if the latter is the case it is possible that future stand openings may be of greater significance.

FOLIAGE DISEASES OF YOUNG DOUGLAS-FIR

Wolf G. Ziller

Damage caused to the foliage of young Douglas-fir in western North America is relatively slight, and the number of pathogens causing the damage is relatively small. Certain pathogens, however, may become more destructive after being introduced, together with their hosts, to new areas, an example being the introduction of Rhabdocline pseudotsugae Syd. from North America to Europe. It is therefore in the interest of international as well as regional forestry to clarify the etiology and life histories of the following four foliage diseases of Douglas-fir.

Phacidium (?) infestans Karst., the cause of snow blight. Snow blight of Douglas-fir in western North America is caused by one of the fungi belonging to the Phacidium infestans complex. Other fungi of this complex cause the same disease to other conifers, mainly pine, in eastern North America and northern parts of Europe and Asia. The damage is restricted to foliage well covered with snow. Only foliage, not the branches bearing it, is invaded and killed by the fungus. Although normally the disease occurs at high altitudes, collections of it have been made in coastal and interior regions of southern British Columbia at altitudes ranging from 1,200 to 4,100 feet. In northern Idaho, the disease has occurred epiphytotically, killing natural reproduction and seedlings in nurseries.

The apothecia of the fungus mature in the summer and fall on the underside of recently killed needles. The asci are approximately 100u long, the 8 spores are ellipsoid to fusoid, slightly colored, 6-7.5 x 18-24u (from B.C. specimens). An abundant growth of gray to dark brown aerial mycelium with minute, black microsclerotia on the surface of the dead needles characterizes the pathogen.

The life cycle of the fungus is completed in one year: infection takes place during late fall, winter, and early spring and is favoured by high moisture and characteristically low temperature, the optimum and minimum being +15 and -5° C., respectively, as reported for the European fungus by Björkman (1). Infection takes place from aerial mycelium or from germ tubes of the wind-disseminated ascospores and occurs by invasion of the needles through their stomata. In spring the infected needles of Douglas-fir turn reddish brown and die, and during the following summer and fall elongate apothecia develop under the lower epidermis of the killed needles, which by that time have turned silvery gray. At maturity the apothecia break through the epidermis and disseminate their ascospores. Most new infections of adjacent young foliage are caused by the aerial mycelium growing out of the recently killed needles. Distant spread of the disease and initiation of new infection centers is brought about by the wind-borne ascospores.

Control has been achieved in nurseries and plantations by spraying with, or dipping in, dormant lime-sulphur. Björkman (1) reports that "needles on plants from northern origin with a higher dry substance ... are not attacked to the same extent as needles on plants of a more southern origin with lower dry substance", indicating that water content of the foliage can be correlated with susceptibility. He observed, also, a direct correlation between severity of disease and thickness of snow cover, suggesting that "a cutting method resulting in the thinnest possible snow cover after felling" would inhibit the development of the fungus.

Rhabdocline pseudotsugae Syd., the cause of needle cast. Rhabdocline needle cast is the most intensively and extensively studied foliage disease of Douglas-fir, partly because of its local damage to young trees in the Pacific Northwest, partly because of the taxonomic and biologic complexity of the causal organisms, but mainly because of its serious effect on Douglas-fir plantations in Europe. "The disease is common throughout the natural range of Douglas-fir in North America and is present to varying degrees in Douglas-fir plantations in the eastern United States and western Europe." (6). It is caused by a number of closely related fungi known under the collective name Rhabdocline pseudotsugae. It has only recently been shown by Parker (5) that several fungi, which are distinguishable from each other by their morphology and/or their life cycles and symptoms, are responsible for Rhabdocline needle cast. Several species of Fungi Imperfecti belonging to the genus Rhabdogloeum are known to cause needle cast similar to that caused by Rhabdocline. They are mentioned in the literature as being the probable imperfect state of Rhabdocline. Parker has found evidence that at least one, Rhabdogloeum pseudotsugae Syd., is not associated biologically with Rhabdocline. Furthermore, Rhabdogloeum is not known to occur in Europe, indicating that it is not a state of Rhabdocline, but a separate fungus which has not yet been introduced to Europe. Only our native Douglas-fir is known to be susceptible to Rhabdocline needle cast, susceptibility varying greatly according to host variety and provenance, and to identity of the pathogen.

The life cycles of each of the fungi causing the disease are similar. They differ chiefly in duration and symptomology: during the period of budbreak, immature needles become infected by wind-borne ascospores which are disseminated from the apothecia on the previous years' living needles. Mature needles, as in the case of needle rust, escape infection, presumably because the mature cuticle acts as a barrier to penetration by the spore germ tubes. The first symptoms in the form of discoloration of the infected needles normally appear in summer and fall. Fruit bodies mature in spring of the following or later years, depending partly on the fungus causing the disease. Infected needles are shed as soon as the ascospores are disseminated. The duration of the life cycle may vary from one to many years, depending partly on the fungus involved.

Control in Europe is achieved mainly by cultivating varieties and races of Douglas-fir which are relatively resistant to infection. The etiology, particularly the degree of resistance by each of the host varieties to each of the various races of pathogens, is still practically unknown. The merit of spraying with systemic fungicides is under investigation. The possibility of forecasting an outbreak on the basis of climatologic data obtained for an infection period is being investigated, also.

Melampsora spp., the cause of needle rust. - Two rust fungi, Melampsora albertensis Arth. and M. occidentalis Jacks., cause foliage rust of Douglas-fir and susceptible species of Populus. Their distribution extends over the natural host range of Douglas-fir wherever it coincides with the range of susceptible poplars: trembling aspen and black cottonwood are the principal alternate hosts for M. albertensis and M. occidentalis, respectively. No rust has been observed on Douglas-fir in Europe. Recent experiments (4) have shown that both rusts can infect species of pine as well as Douglas-fir. The symptoms on Douglas-fir are slight discoloration of the needles in spring, appearance of yellow caeomata, and finally the shrivelling and casting of the rusted needles in late summer and fall. The two rusts are very similar if not identical in life cycle, gross morphology, and pathogenicity, but can be distinguished easily from each other by the size of all spores but the basidiospores (7). Damage has been relatively insignificant with the exception of severe killing of seedlings in a nursery surrounded by susceptible poplars (2, 3).

The following one-year life cycle applies to both rusts: windborne basidiospores from overwintered poplar leaves on the ground infect immature needles of Douglas-fir in spring, one to two weeks after budbreak. Mature needles are immune to infection because of their thick cuticle forming a barrier to spore penetration. Pycnia, and later aecia, appear on the needles approximately two weeks after infection. Aeciospores become wind-disseminated and serve to spread the disease to poplars in June. Uredinia in the summer and telia at the end of the growing season are produced on the poplar leaves, the urediniospores serving to intensify the rust on poplar, and the teliospores after overwintering in the dead poplar leaves on the ground serving to produce basidiospores in spring. The basidiospores cause new infections on the young foliage of Douglas-fir nearby.

Control can best be attained by avoiding the planting of Douglas-fir in the immediate vicinity of susceptible poplars. The disease cannot persist in a locality where one of its alternate hosts is absent. Fungicidal sprays may be practical for use in nurseries where susceptible conifer seedlings are raised.

Bud necrosis. - Bud necrosis of conifers can be caused by various agencies including mineral deficiency, unfavourable climate, insects, or fungi. The disease referred to here is associated with the formation of fruit bodies of a fungus which after seven years' observation is still unidentified and apparently new to science. It is a species of Camarosporium or Hendersonia of the Fungi Imperfecti. This parasite apparently arrests the growth of the shoots soon after budbreak and fruits on the partly-closed buds as conspicuous clusters of black, superficial pycnidia 400-600 mu. high and 330-400 mu. wide. The conidia are remarkable for their length: they are light brown, cylindrical, multiseptate, muriform, 12-16 mu. wide, and 76-110 (125) mu. long. Six collections have been made since 1955, from altitudes between 1,700 to 4,000 feet in central and southern interior regions of British Columbia.

Although of mycological interest only, at present, the fungus appears to be a virulent parasite which under suitable environment could interfere considerably with the normal growth of immature Douglas-fir. Studies of its etiology and taxonomy will be continued.

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WHAT WE SHOULD KNOW ABOUT ROOT SYSTEMS

R. G. McMinn

Increased knowledge of tree roots can expedite the control of disease. Exact information on the spatial arrangement of root systems is needed, for example, because root contacts and grafts are modes of disease spread (Rishbeth 1950, Kuntz and Riker 1956). The role of the different components of root systems needs clarification. The volume and nutrient status of the soil available for rooting is considered to influence vigor and senility (Day 1959). An understanding of the origin of infection courts, of the factors influencing root exudates, and the composition of the rhizosphere are other factors pertinent to the control of disease. The answer then to the question "what should we know about tree roots" is obviously "all we can", for any information can have a bearing on disease control. I am going to mention some specific enquiries which may yield useful results. I hope that others will arise from the discussion.

The extent of root systems is known to be correlated with such factors as tree age, crown class, stand density, site quality and slope (McMinn 1962). However, we have no exact formulae for computing the relation between rooting area or extent with height or crown size. Only when we can say with reasonable certainty that roots of a particular size can be expected at a given density, at certain distances from a tree, can we determine, for example, the minimum size an isolation strip around a root-rot focus must be to have any reasonable expectation of success. Whether tree size alone is an adequate criterion for judging root extent or how values derived from size must be modified on different sites or at different stand densities seems to be unknown. In other cases, existing information is conflicting. The root systems of several trees in immature stands of Coastal Douglas-fir have been found to extend twice as far upslope as they did downslope (McMinn 1962). Other studies on Douglas-fir (Steinbrenner and Gessel 1956; Berndt and Gibbons 1958) and on white pine (McMinn unpublished) revealed that the greatest extent was downslope. Asymmetry is also likely to occur with irregular spacing of trees; roots may extend farther into openings between trees than on the crowded side. Consequently, data are needed on the reasons for and extent of asymmetry as well as on average extent of roots.

Root excavation, followed by measurement of the depth and distance from the root collar of the different size classes of roots of trees of various sizes, ages and crown classes are required to calculate the information necessary to remove prediction of rooting extents from its present status of a guessing game. Since definite information on the size of roots is required, because size may influence a root's longevity as a source of inoculum or its adequacy as a food base, indirect methods, such as the use of radiotracers, which reveal extent and density but not the size of roots, fall short of meeting all requirements.

Such characteristics as the rate of growth into isolation strips of the roots of peripheral trees, the time elapsed before colonization by competing organisms renders different sizes of the roots of felled trees unsuitable for pathogens, and the longevity and difference in colonization rates between grafted and ungrafted root systems of felled trees would all seem amenable to quantitative study and worth determining if isolation of root rot foci is contemplated as a control measure. Excavation of fellings of known ages could later be augmented by the excavation of experimental cuttings.

Tree roots usually ramify throughout the soil profile with some extending downward until an obstructing horizon such as hardpan or bedrock is encountered. A permanent water table also limits the vertical extent of roots. Even within this rooting zone, however, considerable differences in the chemical and physical properties of the soil exist. The absorbing elements of surface lateral roots in the upper soil profile consequently are likely to contribute to the welfare of the tree in a manner different from that of the deep root system in the lower profile. Most of the nitrogen, for example, available from podzolized forest soils is released by the decomposition of the litter deposited on the surface of the mineral soil. Deep horizons usually contain very little nitrogen. On the other hand, absorbing roots in deep soil horizons may perform an indispensable role by supplying moisture when the profusion of roots in surface horizons have exhausted moisture in the upper profile before moisture is depleted in the lower profile. When drought periods are prolonged, deep horizons are likely to hold a reservoir of water available only to plants with deep root systems. Plants without absorbing roots on their deep root system are consequently vulnerable to prolonged drought, and crown dieback may ensue. An interesting example of the relation between top dieback and loss of absorbing deep roots is given by Newhook (unpublished). Chinese gooseberry bushes growing near Aukland, New Zealand, suffered foliage dieback during a prolonged drought period when moisture in the surface soil was depleted. Examination of their deep root systems revealed that few absorbing roots were present, death being attributed to <u>Phytophthora</u> spp. associated with the normally high water table. Adjacent bushes growing where surface soils were irrigated had not died back. Death of much of the deep root system of pole-blight-affected white pine has been noted (McMinn unpublished). The living deep roots of adjacent healthy trees was probably an important factor in their survival.

Experimental evidence on the relative significance of different components of root systems and the crown symptoms resulting from the failure of different absorbing regions should help in the evaluation of disease problems.

Drought shelter experiments are one approach that has been used, for example, to study the origin of pole blight crown symptoms. The lack of typical crown symptoms with shelters used over the past six years to increase summer moisture stress may be related to at least two factors (McMinn unpublished). Firstly, the weather during most recent summers has not been hot for such prolonged periods as it was during most years between 1930 and 1946 (McMinn and Molnar 1959). Trees consequently were likely to have experienced less internal moisture stress than during the earlier period, even when soil moisture was depleted to low levels. Such stress may be an important factor in dieback versus the die-up (reduction of crown size from lower crown upwards) commonly encountered when root rot slowly reduces the absorbing surface area of root systems. A second factor may be the state and environment of the deep root system. The condition of deep root systems will not be known until the trees in the sheltered area are excavated; a functional deep root system could have maintained these trees even when surface moisture is exhausted if, as is likely to be the case, moisture is available in the lower profile.

While the weather impinging on a 100-ft. tree seems currently beyond our means of control, manipulation of the root system, such as amputation or fumigation of specific portions, should augment our understanding of the role of various components. Rowe (1961), for example, raised the possibility that suitable pruning of lateral roots may reduce the internecine competition among the roots of a tree and promote deep penetration by the tap root. Certainly seedlings to be planted on deep but droughty soils should be treated to encourage tap root rather than lateral root extension at the expense of deep roots.

Another area where information seems to be scanty is methods and criteria for assessing the function and vitality of root systems. A comparison of the weight or even the length of two root systems may not be significant because one system could be composed of woody members covered with phellem and devoid of absorbing surfaces, while the other may be composed of elements capable of absorption. Information is required on whether, for example, roots with a collapsed hypodermis are comparable in function with roots having turgid hypodermal cells. Since the former type may constitute a considerable proportion of the non-phellem covered roots, it is worth knowing how efficient they are at absorbing water or mineral nutrients and how they compare with mycorrhizal rootlets. Have seedlings well supplied with mycorrhiza a larger absorbing surface for a given length of root than seedlings with few mycorrhiza? Are mycorrhizal root systems consequently more compact and readily transplantable, and have they a higher survival rate than seedlings with few mycorrhizal rootlets?

When can we expect to outplant trees with root systems tailored to the site, trees which would not only put on good increment shortly after planting, but which may also be relatively resistant to disease because of their vigor? Inoculation of legumes with suitable strains is standard practice by knowledgeable farmers whenever improved growth will accrue. Is the same philosophy inherent in reforestation programs? Attempts have been made in Austria to afforest with stock suitable for high alpine terrain (Moser 1956). Where do we stand on our droughty sites, sites on which poor vigor is commonly accompanied by Armillaria infection?

Understanding the physiological implications of different rootlet types, differentiated on morphological, anatomical or mycological bases should help in our assessment of the degree of reduction in vigor of root systems commonly associated with decline or nutritional disorders.

Observations on various disease problems has led Day (1959) to contend that deficiencies within the rooting zone provide the foundation factors in the development of disease. Aspects of this thesis seem quite acceptable. The death of roots through drought or temporarily high water tables are obvious examples of the manner in which infection courts may be initiated. More controversial is the viewpoint that stands are liable to grow well during initial stages of development when soil depth is adequate to support small trees, but that when the soil is fully occupied most of the dominants are pushing so close to the capacity of the site that a slight reversal of favorable conditions has a major effect on the tree. The failure of dominants, with intermediate and suppressed trees less affected, is contrary to normal expectation during stand development when suppressed trees die and dominants continue to maturity. Day's viewpoint seems based largely on experience of plantations on soils of moderate fertility but limited volume. While many commercial forest types in western North America may not fall into this category, experimental evidence to validate or refute the viewpoint in stands where this sequence may seem to occur would seem well worthwhile. We should be alert to the possibility of the occurrence of high risk sites or climatic sequences. Possible approaches might be through evaluation of spacing requirements for various stand types and the effects of induced reversals by drought, pruning, defoliation, soil ammendments, etc.

The rhizosphere is known to be a two-way street. Soil conditions affect the microflora and the roots of trees; tree root exudates and residues influence the surrounding microflora. Studies implicating an unknown root exudate, the

M-factor of Melin (1962), in the formation of mycorrhiza illustrate both the importance of the physiological state of the tree in controlling the type of exudate and the importance of exudates in controlling the activities of the surrounding microflora. The biochemical constitution of compounds which may retard parasites and yet promote the entrance of mycorrhizal fungi have not yet been elucidated. The next step — how to manipulate the production of exudates to the advantage of foresters — seems still further away. This complex biochemical field seems to be one of the most baffling frontiers of knowledge that must be rolled back in our quest to reduce losses by tree diseases.

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Discussion

In the discussion following the paper, were noted:

Bloomberg: The time of occurrence (of drought, etc.) may be of importance in modifying the exact crown symptoms manifested.

Leonard: Tritiated water injected at a depth of 80 ft. below the soil surface has been recovered in oak trees— an example of the use of isotopes in root studies.

Panel III - Fungus Interactions in Wood Decay

Moderator - R. Bourchier

Introduction

Our topic for discussion this afternoon seems to fall under 3 subheadings: 1) decay in raw forest products; 2) decay in slash; and 3) decay in living trees. The subject matter of these 3 subheadings intergrades of course but I believe it is meaningful and worthwhile to break the subject into these three categories, if for no other reason than the fact that the interests of our speakers this afternoon centre around these headings.

Interest in fungus interactions in wood decay goes back a good many years. Robert Hartig was the father of forest pathology, as we know it, and it so happens that he was the father of that part of forest pathology that we are considering this afternoon. In 1878, Hartig observed the fungus Xenodochus ligniperda, now known as Torula ligniperda, in association with Armillaria mellea in diseased roots. Many workers since Hartig's time have reported mixtures of fungi associated with decayed wood and frequently, non-basidiomycete fungi were found in association with the basidiomycetes which have been traditionally considered as the causal organism in wood decay.

Our first speaker this afternoon is Miss. E. I. Whittaker of the Canada Department of Forestry, Forests Products Laboratory, Vancouver. The title of Miss Whittaker's paper is "Interactions of Fungi Imperfecti, Ascomycetes and Wood-Decaying Fungi", - Miss Whittaker.

Interactions of Fungi Imperfecti, Ascomycetes and Wood-Decaying Fungi[1]

Miss E. I. Whittaker

Introduction

There is a saying "no man is an island" that could equally well be applied to all living organisms including the fungi. The development of a fungal infection is not only dependent on a suitable substrate, moisture and temperature but to a certain extent on the surrounding flora with which the invader must compete or co-exist.

The production of antibiotics by fungi and bacteria is common knowledge but is more often thought of as a special effect. However, this and other chemical and physical factors must be in constant interplay in a mixed natural population of microorganisms.

Soil has a great population of microorganisms, and fungistatic effects have been reported on many occasions. The antagonistic effect can be removed by autoclaving (9). Wood in contact with the ground as in poles and slash can also maintain a mixed population of bacteria, yeast and fungi.

The interior of a healthy tree used to be considered sterile. If some stain, discoloration or decay occurred in the wood, the fungus isolated from that region was usually in pure culture. Mixed infections do occur frequently but the fact that only two or three organisms are involved in one situation makes it easier to study. In the past investigators of the causes of decay often dismissed the Ascomycetes and Fungi Imperfecti as harmless co-inhabitants. It is now recognized that they may

[1]Contribution No. of the Vancouver Laboratory, Forest Products Research Branch, Department of Forestry of Canada.

play a significant role in the development of decay.

Literature Survey

Examples of fungal interaction in the field and in the laboratory are not difficult to find.

Heavy growth of Trichoderma viride mould on southern pine logs was considered responsible for keeping them free from stain and decay (10). Definite antagonisms have been demonstrated by this mould toward decay fungi commonly affecting birch logs in storage (17).

Naturally or artifically induced infections by Peniophora gigantea in Scots and Corsican pine stumps have been found to prevent subsequent infection with Fomes annosus (14). Practical application has been made of this fact to control Fomes annosus root rot in pine plantations.

The effect of sap-stain on decay resistance of lumber has been studied by several workers with varying results. Whether sap-stain is a help or a hindrance to subsequent decay appears to depend on wood species, fungal species and whether the staining fungus is still viable. In some cases sap-stained wood has been found somewhat less resistant to decay fungi than sound-wood (8). In others, the living stain fungi appeared to stimulate the growth of the decay fungus but when killed ceased to have any effect (1). It has been suggested that the decay hazard in the case of sap-stained lumber lies more in the increased porosity of such lumber which permits a greater adsorption of moisture and thus encourages the onset of decay (12).

The effect upon the substrate is an important factor in fungal relationships. In investigations of deterioration in balsam killed by spruce budworm (2) five fungi were isolated in a definite pattern of succession over a two-year period. The initial infection caused by Ophiostoma bicolor and a yeast was followed by Stereum chailletii and an unknown hyphomycete and finally Polyporus abietinus. In the laboratory, none of these fungi showed any special reaction to each other. The succession pattern was attributed to the gradual changes in moisture content and pH of the wood rather than direct fungal interaction.

In living trees there are a number of reported examples of antagonism between both Ascomycetes and Fungi Imperfecti and decay-producing fungi. From eastern balsam fir a heartwood blue-stain fungus, Kirschsteiniella thujina, was isolated which was inhibitory to Stereum sangüinolentum (13). Alternaria spp. from white pine were found inhibitory to Fomes pini (11). The Ascomycete, Coryne sarcoides, a frequent isolate of spruce and lodgepole pine has been found to inhibit Polyporus tomentosus, Coniophora puteana (6, 7), Stereum pini (4, 18), Stereum sanguinolentum and Fomes pini (18).

An interesting situation exists in the heartwood of mature western red cedar. The darker coloured inner heartwood almost invariably harbours a mixed population of hyphomycetes and sometimes yeasts and bacteria. The light coloured outer heartwood is generally free of organisms (5). At a given cross-section, the extractives responsible for the decay resistance of cedar are present in much greater concentration in the outer light heartwood than the inner dark heartwood. The question arises whether these fungi are present because the level of toxic extractives is lower or whether the level is lower because these fungi have somehow altered the extractives to less toxic compounds. In laboratory tests (16) where chemical analyses were carried out on matched samples before and after decay by the fungi Poria incrassata and Coniophora puteana, it was found that the level of thujaplicin had decreased even when weight losses due to decay were relatively low. The suggestion has been made that the thujaplicin was attacked first, either by preference or necessity, before the wood itself. Whether the hyphomycetes are capable of de-toxifying the extractives and creating a central core of lower decay resistance has yet to be discovered. It is a field of study with interesting possibilities.

Experimental Work

Experiences in the Vancouver Laboratory with fungal interaction have been of three kinds: (1) a partnership of two fungi to produce a heartwood stain in hemlock and balsam; (2) the antagonism displayed by C. sarcoides toward three white rot producing fungi responsible for red heart stain of lodgepole pine, and (3) the succession relationship in which a black stain fungus appears to prepare the way for later decay in yellow cedar heartwood.

An unusual rose-pink stain found in hemlock and balsam heartwood is the result of a double infection by two fungi, a Coryne sp. and a Verticillium sp. Each fungus seems capable of growing alone and on agar plates no reaction was observed between them. The curious aspect of the relationship is that the Coryne sp. which colours agar media a deep rose does not cause a typical discoloration in wood unless the Verticillium sp. is present. It might be termed a type of synergism. The activity of the Verticillium sp. must supply something necessary for the production of pigment.

During a study on the causes of red heart stain in lodgepole pine it was observed that C. sarcoides was frequently isolated from typically red stained material but the white rot causing the red heart condition could not be induced to grow. Paired plantings on malt agar plates of C. sarcoides and the fungi concerned, showed that Fomes pini was strongly inhibited, Stereum pini moderately inhibited and S. sanguinolentum only slightly inhibited. Interactions were also tested in wood by infecting sound pine blocks with C. sarcoides and exposing these blocks to soil jar cultures of the decay fungi. Controls of matched uninfected material were similarly treated. The results corresponded well with those of the agar plate tests. Fomes pini decay was the most strongly affected. Weight losses due to decay were much less in the blocks which had been infected with C. sarcoides than in the control blocks. Similarly, decay losses by S. pini were also reduced by the presence of C. sarcoides but the differences were only slight when S. sanguinolentum was involved.

The antagonism between C. sarcoides and decay fungi has been well substantiated both in wood and in laboratory cultures. In all probability its activities in the tree would retard the spread of the red heart condition. The basis for this action remains to be clarified. In situations of this kind there appear to be three possibilities, namely, the competition for available food, the alteration of the substrate or general conditions to the detriment of the other fungi or the production of an antibiotic substance. The latter seems the most attractive explanation because the inhibitory effect was produced both on wood and on agar, but further work is necessary before this can be established.

An entirely different situation was presented by two fungi provisionally designated "A" and "C" which produce a black stain in the heartwood of yellow cedar. These fungi have been placed in the Sphaeropsidales until further identification is made. It was noticed that zones of incipient and advanced decay frequently coincided with the black stained areas. Decay fungi, Poria weirii, P. asiatica and Xeromphalina campanella, were isolated from the affected wood and paired with the stain fungi on malt agar plate cultures. No marked effects were observed (15).

Decay tests on naturally stained wood in soil jar cultures of building rot fungi Poria incrassata, Lenzites saepairia and Fomes roseus demonstrated that this wood was much less decay resistant to all three fungi than adjacent sound wood. Similar tests employing matched yellow cedar strips, some infected with Fungus A, some with Fungus C and the remainder uninfected, confirmed this pattern with respect to Fungus C.

Results for Fungus A were mixed. Poria incrassata seemed unaffected by its presence. Decay by Lenzites saepiaria was increased and decay by Fomes roseus appeared to be inhibited although in the latter instance, differences were not statistically significant.

Each of the stain and decay fungi was planted in pairs on malt agar plates. The only appearance of an inhibitory action was the Fungus A-Fomes roseus combination where a zone of incomplete inhibition persisted for some time before eventual intergrowth of the colonies. Growth of P. incrassata actually advanced faster over the mat of Fungus C than on the adjacent agar surface.

The activity of the two fungi A and C in wood differed greatly. "C" was able to cause a small weight loss in yellow cedar although strength was not affected. Fungus A was less active and caused no weight loss.

The increased susceptibility of Fungus C - stained yellow cedar might be accounted for in three ways. Fungus C may alter the normal extractives of yellow cedar thereby reducing its inherent decay resistance. It may cause an increase in porosity of the wood, making it easier for decay to start. It may be producing a growth stimulating substance which encourages the decay fungi. There may be a combination of factors involved. The alteration of extractives appears the most likely solution as this would have an effect of greater magnitude than would be expected from the other two possibilities.

The activity of Fungus A is of a different nature as the three decay fungi all responded differently. Something was produced which favoured the growth of L. saepiaria but not the other fungi.

Conclusions

From the examples given it can be seen that the development of decay can be stimulated or hindered by the growth of other organisms. An explanation of the phenomena can only be suggested until more work has been done on the metabolism of these fungi. The factors to be considered are metabolic products of the fungi, and physical and chemical changes in the wood substrate, such as pH, moisture and loss of natural extractives.

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TEMPERATURE AND THE DISTRIBUTION OF FUNGI IN LODGEPOLE PINE SLASH

A. A. Loman

A complex of Basidiomycetes, Ascomycetes, Fungi Imperfecti and bacteria inhabit the wood of lodgepole pine logging residues. Decay activity and associative effects between slash inhabiting organisms are influenced by the substrate and its continual physical and chemical changes resulting from the decay processes, and by fluctuations of moisture content and temperatures resulting from exposure to precipitation and isolation.

In an attempt to determine the identity and significance of fungi associated with the decay of lodgepole pine slash (2), an interesting fungus distribution within the slash came to light, suggesting that the environmental factors of moisture and temperature were more significant in determining the preferred areas of certain fungi, than associative effects between organisms or the factors involving the chemical and physical nature of the substrate.

The role of moisture and temperature and its influence on the activities of decay fungi is of particular importance in dry continental climates and at high elevations. In Alberta, the merchantable lodgepole pine forests occur within a range of 16 to 24 inches of annual precipitation, three quarters of which falls during the growing season. Elevations range between approximately 2500 to 4500 feet. The combined effect of high elevations and relatively low annual precipitation results in considerable differences of moisture and temperature conditions between exposed and sheltered locations.

These differences were evident on 7-year old lodgepole pine slash. The upper exposed surfaces of slash in clearcut areas had lost all or most of the bark and consisted of a thin shell of casehardened wood, several growth rings deep and broken by numerous shrinkage cracks of variable dimensions and depth. These shrinkage cracks provided entrance courts to slash decaying fungi, particularly *Lenzites saepiaria* (Wulf. ex. Fr.) Fr., and *Peniophora phlebioides* Jacks. & Dearden. Excepting an occasional sporophore of *Lenzites saepiaria* or *Trametes americana* Overh., fruiting-bodies did not normally develop on upper surfaces. The lower sheltered surfaces of slash however, particularly of slash in contact with the ground, had retained much of the bark on which large numbers of sporophores of a variety of species were normally found.

Determinations of the identity of fungi associated with stain or decay by cultural means is a standard procedure in volume and decay analyses. All cultural isolates attempted from seven-year old lodgepole pine slash originated from areas near the top, centre, and bottom of the slash interior. The relative frequency of isolates of eleven basidiomycetes in the upper, central and lower portions of lodgepole pine slash for clearcut and partially cut areas, suggested a number of interesting possibilities:

1. The relative frequency of cultural isolates of each species from the different slash areas, was an indication of the preferred locations of the Basidiomycetes within the slash.

2. The fungi predominating in the upper and central slash portions were more common in clearcut than in partially cut areas, while the reverse held for fungi predominating in the lower slash portions. Presumably, general microclimatic differences that exist between clearcut and partially cut areas exist to a greater extent between upper exposed, and lower sheltered portions of the same pieces of slash within clearcut areas.

3. The fungi that predominate in the upper exposed areas are likely to tolerate greater extremes of moisture and temperature than the fungi that are restricted to the lower sheltered portions of slash.

Lenzites saepiaria, Peniophora phlebioides, Stereum sanguinolentum Alb. & Schw. ex Fr. and Coniophora puteana (Schum. ex Fr.) Karst. were represented approximately 80 out of 100 times in all basidiomycetous cultural isolates. Because of their predominance over the other basidiomycetes, all laboratory growth and decay tests were conducted with these four species.

Temperature relations, moisture requirements and decay capacities are fairly well known for Lenzites saepiaria, Stereum sanguinolentum and Coniophora puteana on an individual basis. To my knowledge no experiments have been done to determine the influence of temperature on their decay capacity on a comparative basis. Excepting descriptions of its sporophore and cultural characteristics, little is known of Peniophora phlebioides.

Summary of results:

Results of temperature-growth rate studies conducted on 2% malt agar in 90 mm. Petri plates may be summarized as follows: The two fungi predominating in the upper and central slash regions, namely Peniophora phlebioides and Lenzites saepiaria, showed higher temperature optima and greater temperature ranges for growth on agar than Coniophora puteana and Stereum sanguinolentum, which were found to predominate in the lower slash portions. Growth rates were rapid for Peniophora phlebioides at all temperatures, excepting at 10 and at 45°C. They were considerably slower for the remaining three test fungi.

Results of temperature-decay rate studies may be summarized as follows:

1. Optimum temperatures for mycelial growth on agar and for decay rate of lodgepole pine test blocks do not coincide for Peniophora phlebioides and Coniophora puteana. Gäumann (1) believes that each of the enzymes (Lenzites spp. produce 117) produced by a fungus has its own temperature range and optimum, and its own function. Discrepancies between temperature optima for growth on agar and for decay of lodgepole pine test blocks presumably coincide with similar discrepancies between temperature optima for the respective groups of enzymes involved in these two different processes. A similar hypothesis may be advanced in the case of Coniophora puteana, where temperature range for decay of pine blocks extends

considerably beyond the lower and higher temperature extremes for mycelial growth on agar.

2. Although it was frequently isolated from 7-year old lodgepole pine slash, Stereum sanguinolentum is a weak participant as a decay organism.

3. Decay capacities of Lenzites saepiaria and Coniophora puteana decrease rapidly at temperatures higher than optimum, while the decay capacity of Peniophora phlebioides decreases more slowly. At 38°C, Peniophora phlebioides is the sole decayer of significance.

4. Decay capacities, expressed as a weight loss percentage of initial ovendry weight of lodgepole pine test blocks after 12 weeks of incubation, for all temperatures averaged: Lenzites saepiaria 17.26%; Peniophora phlebioides 13.61%; Coniophora puteana 13.96%; and Stereum sanguinolentum 4.29%.

Results of an experiment to test the survival of mycelium in lodgepole pine test blocks when subjected to high temperatures for variable lengths of time are as follows:

Coniophora puteana was killed after 80 minutes of exposure to 45°C, and after 30 minutes of exposure to 52°C.

Stereum sanguinolentum was killed after 180 minutes of exposure to 45°C, and after 60 minutes of exposure to 52°C.

Lenzites saepiaria survived 220 minutes of exposure to 59°C, and was killed after 110 minutes of exposure to 66°C.

Peniophora phlebioides survived 220 minutes of exposure to 59°C, and was killed after 10 minutes of exposure to 66°C.

Interior slash temperatures were recorded in July at upper, central and lower locations corresponding with the locations of origin of the cultural isolates. Temperatures were recorded by means of thermo-couple wires and a Rubicon portable potentiometer, as described in the section "New or Modified Techniques" in the 1961 W.I.F.D.W.C. Proceedings.

The temperature range was greatest in the upper and smallest in the lower interior slash areas. During clear warm days upper and central slash temperatures would exceed limits for decay activity of all fungi for the greater part of the day. Slash temperatures would be favourable for decay in the early mornings and late evenings for all fungi, with considerably longer periods for the high temperature tolerating fungus

Peniophora phlebioides.

During clear warm days, mycelium of Coniophora puteana and Stereum sanguinolentum presumably is killed in the upper and central portions of slash while Peniophora phlebioides and Lenzites saepiaria are capable of withstanding the high temperatures recorded.

During overcast and rainy weather-conditions the slash temperature range would remain within limits suitable for decay by all fungi day and night. The relatively rare occurrence of low temperature fungi in the upper and central portions of slash may be the result of periodic re-invasions of mycelium, during sustained periods of rain or overcast skies, into those portions of slash where they were killed by heat.

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FUNGUS INTERACTIONS ON WOOD DECAY

R. Bourchier

Workers in this field of fungus interactions, as it pertains to wood decay, are not really very numerous. After making several attempts to interest someone else in presenting a paper at this gathering, I was forced, somewhat reluctantly, to the conclusion that I should have been a panel member rather than a moderator because my research interests, since 1957, have been right along the lines of our subject this afternoon. However my mandate from the program chairman included a clause to the effect that I could say anything I liked. Accordingly then I would like to tell you a bit about my work with a group of fungi found in the heartwood of living lodgepole pine in Alberta.

A total of 80 trees were dissected in this study. They were in 4 age classes of average age 19.2, 38.5, 63.9, and 82.5 years respectively. In all, 5,710 culture attempts were made at 2 foot intervals in the boles of the trees. Cultures were attempted from the pith, the heartwood, and the sapwood. This pattern of cultural attempts was followed regardless of whether there was any stain or decay present. A total of 1,409 cultures produced growth, 574 of which were micro-fungi in 16 genera. 605 were Peniophora pseudo-pini (Stereum pini), 56 were other Basidiomycetes, and 174 were miscellaneous fungi, bacteria, and mixed cultures.

The 2 most frequently isolated fungi were Tympanis hypopodia (187 isolates), and a Coryne sarcoides complex, (81 isolates). Other fungi in decreasing order of isolation frequency were: a Fumago-like fungus, Aureobasidium pullulans, Zythia resinae, Taeniolella sp., Cladosporium herbarium, Retinocyclus abietis, Oidium corticale, and Cephalosporium nordinii. Many of these occurred apparently indiscriminately at various levels in the bole and in pith, heartwood, and sapwood. The two most frequently isolated fungi, however, were obviously pith and heartwood inhabitors of the lower bole.

Concerning tree age and fungus incidence, all but one fungus, A. pullulans, were more common in the older trees. Three species of micro-fungi were found in the 20 year old trees and 16 species in the 80 year old trees. Aureobasidium pullulans' reputation as a ubiquitous fungus was enhanced; it was found 8 times in the 20 year old trees and 14 times in the 80 year old material.

Most of the micro-fungi encountered in this study were isolated more frequently from apparently sound wood than from stained or decayed material. 90% of the isolates of many fungi were from apparently healthy wood and for some fungi, 100% of the isolates were from this source. Two fungi, Cephalosporium nordinii and a species of Tympanis, were isolated more often from red-stained wood. All the micro-fungi isolated in this study were obtained at least once from apparently sound wood and a good many from completely sound trees.

Four stocks of the 9 most frequently isolated fungi were tested for possible antagonism with Peniophora pseudo-pini (Stereum pini) on malt agar plates. No marked inhibition zones were noted but there was some inhibition of P. pini growth by C. sarcoides complex, R. abietis, and T. hypopodia. When pine wood blocks were first inoculated with these 3 fungi and 3 months later inoculated with P. pini, the latter fungus showed reduced activity as measured by weight loss, on the blocks first inoculated with C. sarcoides complex and T. hypopodia but enhanced activity on the blocks previously inoculated with R. abietis.

To investigate this inhibition further, shake cultures of C. sarcoides complex and T. hypopodia were grown on 20 ml. of malt extract for 1 month. The culture media were then filtered and the filtrate extracted with amyl acetate. This extract was then tested for antibiotic activity against P. pini using the familiar filter paper disc method on Petri plate cultures. The filtrate from 1 stock of the C. sarcoides complex was slightly inhibitory against P. pini, indicating that antibiosis was the mechanism involved rather than competition for nutrient materials.

Some stocks of 3 species of micro-fungi caused small weight losses in pine test blocks after 3 months incubation. The losses were of the order of 1/2 of 1% and the fungi were T. hypopodia, C. sarcoides complex, and A. pullulans.

In conclusion the following 4 points seemed to stand out: 1) a rather constant flora of non-basidiomycete fungi occurs in pine heartwood (living trees); 2) a succession of fungi is strongly indicated, whether it is necessary for wood rot establishment is not clear; 3) some of these micro-fungi can cause measurable decay as determined by weight loss; 4) the significance of the presence of these micro-fungi in wood used for decay capability tests of Basidiomycetes is important.

I would like to thank Miss Whittaker and Mr. Loman for the part they played in this panel this afternoon and also, thanks to you, the audience, for your interest and participation.

FOREST DISEASE SAMPLING IN DOUGLAS FIR PLANTATIONS

R. E. Foster

The incidence of forest disease is highly variable between and within Douglas fir plantations. This finding suggests (1) that it is desirable to utilize sequential sampling techniques to segregate areas of interest or concern in which there would be justification for more detailed, subsequent examinations; and (2) that precision sampling may require very high sampling intensities; guides to these intensities have been developed for different diseases, different populations, and different levels of desired precision. It was pointed out that acceptable errors should be selected in relation to the specific objectives of a survey and to the non-sampling errors present.

NEEDLE-CAST AND NEEDLE-BLIGHT FUNGI
ATTACKING SPECIES OF PINUS IN SOUTHWESTERN FORESTS

Paul D. Keener

Taxonomy: Elytroderma deformans (Weir) Darker is still a frequently encountered needle-cast pathogen on Pinus ponderosa Laws., in the various National Forests of Arizona and New Mexico. It occurs either alone or in combination with other needle-cast or needle-blight fungi. "Infection centers" are limited in numbers and extent, and are widely scattered throughout the few remaining virgin stands of this species of Pinus.

Elytroderma deformans also infects needles of Pinus edulis Engelm. and P. cembroides Zucc. The former pine is of economic value because of the Pinon nut crop. Pinon nuts yield considerable income for certain Indian tribes in the Southwest.

In the case of attack by Elytroderma deformans the positions of the fruiting bodies and their respective spore forms are variable, depending on the species of Pinus on which the fungus occurs. On needles of Pinus ponderosa fruiting of the fungus may occur at any position throughout the entire needle length. At times a single hysterothecium is involved; at others more than one. On P. edulis and P. cembroides, fruiting bodies are almost invariably confined to the mid-points of needles, although endophytic mycelium is usually found throughout the mesophyll, extending considerable distances beyond the limits of the sporocarps.

Not generally mentioned in the literature is the production of brooming by Elytroderma on Pinus edulis. Brooms are common and have been described as occurring rather regularly on Pinus ponderosa. Well-formed brooms, much longer than wide, have been noted on infected trees of Pinus edulis on the South Rim of the Grand Canyon, within the boundaries of Grand Canyon National Park, and on the North Kaibab National Forest, near Jacob Lake. No Elytroderma-induced brooms have ever been noted on Pinus cembroides.

On needles of Pinus ponderosa, especially those found in the massed materials of witches'-brooms, other fungi are commonly present, thus forming a complex caused by the simultaneous presence of more than one organism. The usual "secondary fungus" is Hemiphacidium planum (J. J. Davis) Korf (Helotiales: Family: Hemiphacidiaceae (2)). This fungus has been found on needles of Pinus ponderosa most frequently in combinations with Elytroderma, less often with Hypodermella medusa, and rarely alone unaccompanied by any other needle-attacking organism. Hemiphacidium appears to be present also to a limited extent on needles of Pinus strobiformis on the Coronado National Forest, Arizona.

Hypodermella medusa Dearn., another commonly encountered pathogen on P. ponderosa in the Southwest, is perhaps the most conspicuous of all of the needle-cast fungi in this region. Studies indicate that this fungus seldom, if ever, causes the extensive needle tissue damage that accompanies attacks by Elytroderma.

Another needle-cast pathogen on Pinus ponderosa fruits in areas resembling small blisters, concolorous with the needle surface. This fungus resembles both Hypodermella concolor (Dearn.) Darker, and H. montivaga (Petrak) Dearness., but is not identical to either. This pathogen has been found in all of the National Forests in Arizona and in some of those in New Mexico. The fungus nature of the "concolorous blisters" was first noted by personnel of the United States Department of Agriculture Forest Service, particularly by Drs. Stuart R. Andrews (Rocky Mountain Forest & Range Experiment Station, Fort Collins, Colorado), Lake S. Gill, formerly Chief of Forest Diseases Investigations (Fort Collins), and Wallace Eslyn (formerly stationed at the U. S. Forest Service, Forest Insect & Disease Laboratory, Albuquerque, New Mexico; now at the Forest Products Laboratory, Madison, Wisconsin). The fungus causing these symptoms is difficult to find in a fully-matured state and producing ascospores. The fruiting bodies, although resembling hysterothecia, should possibly be considered as being intermediate structures similar to both hysterothecia and apothecia. The absence of fungus tissue (exciple) over the apex of the fruiting body, even though the latter is definitely "of a locule-in-the-tissue" nature, makes the taxonomic status of this organism questionable. The fungus is as wide-spread on needles of Pinus ponderosa as Hypodermella medusa and more so, in some areas, than Elytroderma. The locules, embedded in the needle tissue, often are sites for the colonization of "secondary fungi" such as Davisiella sp., and a species of Phaeoseptoria.

Histopathology: Elytroderma deformans was observed in all needle-tissues in infected Pinus ponderosa, P. edulis and P. cembroides.

The activity of Hemiphacidium planum, either alone (rare) or in combination with Elytroderma could not be accurately ascertained at times because of the paucity of mono-infections and, when both fungi were present, complications caused by the known activity of Elytroderma. However, in the few instances in which Hemiphacidium was accompanied by Hypodermella medusa, all tissues were observed to be occupied by fungus mycelium. Since it is fairly certain that the latter does not invade tissues other than the mesophyll, to any extent, the observed destruction of phloem in such needles was possibly due to Hemiphacidium. Additional histopathological data indicate that the action of Hemiphacidium alone on needle tissues in Pinus ponderosa is similar to that which would be expected if only Elytroderma was present.

Table 1 shows the number of endodermal cells (outer limits of the vascular cylinder) found to be invaded by hyphae of Hemiphacidium as ascertained from a study of 25 transverse sections through infected needles of Pinus ponderosa.

Table 1. Numbers of endodermal cells occupied by hyphae of Hemiphacidium planum (Davis) Korf, as observed in transverse sections through needles of Pinus ponderosa Laws. Data chiefly from materials from North Kaibab National Forest, Arizona. Orseillin BB + Sartory's solution technique.

Section No.	Total number of endodermal cells in section	Number of endodermal cells occupied by fungus hyphae	Number of endodermal cells free of hyphae
1	40	13	27
2	41	13	28
3	40	7	33
4	41	8	33
5	43	6	37
6	40	5	35
7	38	6	32
8	43	18	25
9	39	7	32
10	39	9	30
11	42	6	36
12	43	9	34
13	42	12	30
14	41	14	27
15	41	14	27
16	41	18	23
17	40	12	28
18	42	15	27
19	43	15	28
20	41	11	30
21	41	11	30
22	41	14	27
23	41	10	31
24	42	12	30
25	41	31	10
Totals: for 25 Sections	1026	296	730
Averages:	41	11.8	29.2

The hyphae appear to enter the endodermal cells through pits in the walls, and progress from there into the transfusion tissue. In many instances the transfusion cells become hypertrophied. In addition to this reaction, a great number of sclerenchyma cells are usually present within the endodermal ring of infected needles. According to some anatomists, this phenomenon of "extra sclerenchyma cells" is also known to occur in needles which have been subjected to drouth. Since trees in the area in which these studies were conducted have undergone several seasons of drouth stress, the production of additional sclerenchyma within the vascular elements, might be due to moisture stress factors, rather than to fungus invasion.

The production of "extra resin ducts" was also a feature of needles attacked by either Hemiphacidium or Elytroderma or both in Pinus ponderosa. These, like the extra sclerenchyma cells, usually were found inside of the endodermal ring.

By far the greatest tissue damage caused by either Hemiphacidium alone or in multiple infections with Elytroderma or by Elytroderma alone was to phloem elements. Contrary to some previous observations, hyphae were readily distinguished coursing intercellularly in the phloem and later actually replacing the phloem tissue. This phenomenon was noted in both P. ponderosa and P. cembroides needles invaded by Elytroderma.

Some of the interesting needle tissue vs. pathogen relations in several species of Pinus observed to date, along with those needing further investigation, are shown in Table 2.

Table 2. Summary of Histological Data: Needle-cast vs. needle-blight fungi vs. needle tissue relationships. Data from materials collected in several National Forests in Arizona and New Mexico.

Fungus	On needles of	Needle-tissue Relationships[1]				
		Mesophyll	Intra-endodermal cell invasion	Trans fusion tissue	Vascular elements: Phloem[a]	Vascular elements: Xylem
Coryneum cinereum	Pinus ponderosa	+ (2 hyphal types)[b]	?	?	?	?
Elytroderma deformans	Pinus ponderosa	+ (2 hyphal types)[b]	+	+	+[a]	slight
Elytroderma deformans	Pinus edulis	+ (2 hyphal types)[b]	+	+	+[a]	?
Elytroderma deformans	Pinus cembroides	+ (2 hyphal types)[b]	+	+	+[a]	slight
Hemiphacidium planum	Pinus ponderosa	+ (2 hyphal types)[b]	+	+	+[a]	moderate
Hypodermella arcuata	Pinus strobiformis[c]	+	+ (slight)	?	?	?
Hypodermella cerina	Pinus ponderosa	+	?	?	?	?
Hypodermella concolor	Pinus ponderosa	+	?	?	?	?
Hypodermella conjuncta	Pinus strobiformis[c]	+	+	?	?	?
Hypodermella medusa	Pinus ponderosa	+	?	?	?	?
Hypoderma sp. Ariz. variant	Pinus edulis[c,d]	+	+ (slight)	?	?	?
Lecanosticta acicola	Pinus edulis	+ (2 hyphal types)[b]	+ (slight)	?	?	?

See footnotes on following page.

FOOTNOTES FOR TABLE 2.

[?] Insufficient data at this time to warrant an opinion.

[1] In many cases, multiple simultaneous infections by more than one needle-attacking fungus on the same needles, may have complicated the indicated observations.

[a] Phloem elements eventually replaced by fungus mycelium. This is in contrast to many previous reports.

[b] Two hyphal types - one of wide diameter with narrow lumen and a comparatively narrow kind with the usual wall vs. lumen ratios, occurred in the same section.

[c] Apparently new host records for these needle infecting fungi, at least in Arizona and New Mexico.

[d] This species of needle-cast fungus exhibits characteristics usually ascribed to both H. saccatum and H. pini (1).

Possible New Host Records vs. Needle-cast and Needle-blight Fungi.

As indicated in Table 2, Hypodermella arcuata and H. conjuncta were found on Pinus strobiformis on the Coronado National Forest. As far as can be ascertained this Pine has not been reported as being attacked by these needle-cast pathogens.

In addition, the peculiar needle-cast fungus fruiting in locules without surrounding fungus tissue on Pinus ponderosa, and identifiable by the production of blisters concolorous with the needle surface, has not been previously reported in the literature.

A needle-cast pathogen resembling both Hypoderma saccatum Darker and H. pini (Dearn.) Darker but not identical to either, is common on Pinus edulis at South Rim of the Grand Canyon, within the boundaries of Grand Canyon National Park, and on the North Kaibab National Forest. This fungus is possibly a variant of either one of the two previously reported species of Hypoderma on this host (1).

What has been identified by personnel of the National Fungus Collections, USDA Beltsville, Maryland, as Lecanosticta acicola (Thuem.) Sydow is rather common as a tip-blight fungus on Pinus edulis on slopes of Mingus Mountain, Prescott National Forest.

Dothistroma pini Hulbary was observed on needles of Pinus strobiformis in Arizona.

References

1. Darker, G. D. 1932. The Hypodermataceae of conifers. Arnold Arb. Harvard Univ. Contrib. 1, 131 pp. 27 pls.

2. Korf, R.P. 1962. A synopsis of the Hemiphacidiaceae, family Helotiales (Discomycetes) causing needle-blights of conifers. Mycologia. 54(1):12-33.

THE STORY OF ROSELLINIA AND BOLETUS (AN EPIC)

(With abject and profuse apologies to Drs. Prince, Faull, Arthur, and Hartig the Younger) by James L. Haskell.

I

In time of old, quite long ago, when atoms had no fame
There lived a small Gnomonia, Boletus was his name,
He lived in far Endothia; a parasite was he
And tracked the wily Stroma and Thelephoraceae.
He was a mighty hunter, and at times he could defeat
The three-toed Ganoderma and the snarling Isogamete.
His prowess was amazing, and he was handsome, too,
For in all of wide Endothia there were but very few
Whose Hyphae were more rugged, or who had more silky fur,
Or who had Paraphyses like Boletus' 'physes were!

II

One morning this great hunter tossed off a pint of rum
And started out to trap a Gymnosporangium.
The weather was delightful, and through the whispering trees
Conidiospores were swinging, and little Clavipes
Were trilling out their love-songs o'er and o'er and o'er
And saying: "No one ever laid a bigger oospore."
The Swarmspores all were swarming, and Rhizoids, blithe and gay,
Rose up in shining clusters all along Boletus' way.
And though game was not plentiful, Boletus didn't care,
He plucked a Spermagonium and stuck it in his hair.

III

Now, as Boletus journeyed, a clearing came his way.
He started to traverse it, then rooted did he stay!
"Pyrenomycetales!" was all his tongue could say,
For, there resupinate upon a rock, fair Rosellinia lay.
Her form was most delightful, her bosom globosom,
He knew he'd never seen a cuter Perithecium!

His Stipe became effuse-reflexed, his tongue was ungulate,
At sight of Rosellinia, his eyes were stipitate!
He wiped the Fomes from his lips and gave a happy cry
As Rosellinia wakened, and blushing caught his eye.

IV

He rushed into the clearing and knelt beside her feet
(Which were resting at the moment on a Basidiomycete).
His soul poured forth impassioned words in wild accents necrotic,
"Oh Rosellinia, fair one, let us be dikaryotic!
Of Parasites and Saprophytes you are the very queen,
You are the fairest Fungus that I have ever seen!
For, though I loved Tilletia, she was just a Stinking Smut,
And compared to you, my dear one, she was nothing but a slut!
Oh, let us Fusicladium, and in a year or more,
Perhaps we will be blessed with a small Chlamydospore!"

V

And Rosellinia answered by whispering in his ear,
"My Boletus, I adore you, I will be your very dear."
And as with passion tender, a kiss he did collect,
She threw her soft Flagella round about his pulsing neck.
But though they found a small Pycnidium, and moved in right away,
The remainder of the story is not happy, sad to say.
For her Hymenium was a thickened, inoperculated wall,
And his Mycelia were Sterilia; he had no Spores at all!
And though they strove most mightily, no Chlamydospore had they,
And she left him for another, and with the other went away.

VI

Poor Boletus was unhappy, he was Melanconiales.
Without fair Rosellinia, blackening gloom his heart did seize.
He drove off in his Buick Autobasidiomycete
To the old Waldorf-Haustoria, where a room-clerk he did meet
And vented on the hapless fellow quite a bit of Chlorosplenium,
(For Boletus by this time was becoming Hysterothecium).
Hydnaceae in his room, he read all the Columellae
(Walter Winchell, Lucius Beebe, and all those other fellows)
Wanting news of Rosellinia. But a rasping, hacking cough
Turned into Tubercularia, and he died of damping-off.

(By James L. Haskell, prepared for the informal initiation of Xi Sigma Pi, University of Maine, 1947.)

APPENDIX I

ACTIVE PROJECTS - NEW

(Projects leaders' affiliations and addresses are given in membership list - Appendix VIII.)

C. Cone, Seed, and Seedling Diseases

62-C-1 Pathological failures of true fir seed. Objective: To determine the part played by disease in the poor quality of seed of these species. (G. Harvey)

D. Root and soil borne diseases or relationships.

62-D-1 Diseases of marginal ponderosa pine, piñon and juniper in Arizona and New Mexico.

Objective: To determine if plant parasitic nematodes or adverse mycorrhizal relationships are associated with loss of vigor and mortality following prolonged drouth. (J. W. Riffle)

62-D-2 Diseases of seed, seedling, and young trees (Robert V. Bega and Richard S. Smith)

Objective: To identify the causal agents involved in diseases of seed, seedlings, and young trees used in natural and artificial regeneration, and to determine the etiology of the diseases.

62-D-3 The epidemiology and host parasite relations involved in the charcoal root disease complex of *Pinus lambertiana* (Richard S. Smith)

Objective: To determine the etiology of the root disease caused by *Macrophomina phaseoli* and to determine the rate of reinvasion of soil pathogens into nursery soil after fumigation.

E. Foliage diseases

62-E-1 Survey of needle cast diseases in the central Rocky Mountains.

Objective: To develop a formal study investigating the etiology, ecology, and significance of coniferous needle casts in the central Rocky Mountain area. (J. M. Staley)

62-E-2 Ontogeny and Cytology of the species of Hypodermataceae of Conifer in North America. (C. C. Gordon)

Objectives: To show the ontogeny of the ascocarps of the species within the 5 genera, *Hypodermella*, *Hypoderma*, *Lophodermium*, *Bifusella*, and *Elytroderma*. To find morphological evidence of the interrelationship of the existing species within the Hypodermataceae and their phylogenetic position within the Ascomycetes. To prepare an illustrated monograph of the species belonging to the Hypodermataceae of conifers in North America.

F. Stem diseases - malformations, witches'-brooms, dwarfmistletoes, etc.

62-F-1 Ballistics of dwarfmistletoe seeds

Objective: To determine the flight characteristics of dwarfmistletoe seeds including velocity, acceleration, and flight. (T. E. Hinds, F. G. Hawksworth)

62-F-2 Field cultures with dwarfmistletoes.

Objectives: By artificial inoculations, determine (1) the ages of host tissue susceptible to infection, (2) the yearly variation in successful infection, and (3) the ontogeny of dwarfmistletoe plants. (F. G. Hawksworth, T. E. Hinds)

62-F-3 Taxonomy, hosts, and distribution of the mistletoes in the Rocky Mountains and the Southwest.

Objectives: (1) To unravel the taxonomy of *Arceuthobium* in the Station's territory and, (2) to determine the hosts and geographic distribution of *Arceuthobium* and *Phoradendron* in this area. (F. G. Hawksworth)

62-F-4 Cytotaxonomic study of the *Arceuthobium campylopodum* and *A. vaginatum* complexes.

Objective: To survey the chromosome numbers and possibly their morphology in the various members of the *A. campylopodum* and *A. vaginatum* complexes. (Del Wiens)

62-F-5 Barriers to dwarfmistletoe infection in non-susceptible hosts.

Objective: To determine why dwarfmistletoe seeds (which germinate and readily form holdfasts) are not able to infect certain non-susceptible hosts. (F. G. Hawksworth)

62-F-6 Effects of dwarfmistletoe on growth and mortality in immature ponderosa pine.

Objective: To determine the effects of dwarf-mistletoe on growth and mortality in immature ponderosa pine in the central Rocky Mountains and Southwest. (F. G. Hawksworth, P. C. Lightle, T. E. Hinds)

62-F-7 Ecology of lodgepole pine dwarfmistletoe.

Objective: To determine the ecological factors (site, topography, ground cover, soils, altitude, etc.) that affect the occurrence and abundance of this mistletoe. (F. G. Hawksworth)

62-F-8 Ecology of ponderosa pine dwarfmistletoe.

Objective: To determine the ecological factors (site, topography, ground cover, soils, altitude, latitude, etc.) that influence the occurrence and abundance of this mistletoe. (F. G. Hawksworth)

62-F-9 Resin disease of lodgepole pine dwarfmistletoe.

Objective: To determine the causal agent and to study the epidemiology and biological control potential of this disease. (F. G. Hawksworth)

62-F-10 Silvicultural control of ponderosa pine dwarf-mistletoe.

Objective: To determine the effects of various treatments (cutting, poisoning, pruning) of infected overstory trees and advanced reproduction. (Four separate studies involving several management objectives). (P. C. Lightle)

62-F-11 Physiological studies of seed of dwarf-mistletoe of ponderosa pine.

Objectives: General exploratory studies. (K. Beckman)

62-F-12 Physiological studies of dwarfmistletoe of ponderosa pine. A comparison of metabolites in host and parasite. (L. McDowell)

62-F-13 Ontogeny of the aerial shoots of Arceuthobium douglasii and A. campylopodium f. laricis.

Objective: To follow the morphological and cytological development of these dwarf mistletoes from the time the aerial shoots erupt through the bark to pollen or seed production. (Bill Jones M.S.U. Graduate Student).

62-F-14 A study of the factors influencing seed production of Arceuthobium americanum on lodgepole pine (J. E. Nighswander).

Objective: (a) Determine the effects of varying light intensities on flower production; (b) determine the effects of temperature on bud break of flowers, pollen viability, pollen germination, pollination, fertilization; (c) determine if A. americanum is entomophilous or anemophilous; (d) investigate the effect of aspect on the volume production and dispersal of seed.

62-F-15 Use of aerial photography in detecting dwarfmistletoe infected lodgepole pine stands (J. A. Baranyay).

Objectives: (a) Determine the relative effectiveness of panchromatic, infra-red, and colour films for detecting infected stands in aerial photography; (b) determine the best film-filter combinations and elevations or scale for aerial photography; (c) determine the lowest intensity of dwarf mistletoe infection that can be detected; (d) work out a practical method for extensive use of aerial photography for dwarfmistletoe detection.

G. Stem Diseases - Stains and Decays

62-G-1 The response of heart rot fungi to extracts of host and nonhost wood (Hubert H. Bynum, Jr.).

Objective: To determine whether the growth of test isolates of Echinodontium tinctorum, Fomes pini and Polyporus amarus is stimulated or retarded by extracts made from white fir, Douglas-fir and incense cedar.

62-G-2 Red rot in merchantable ponderosa pine in the Black Hills.

Objective: To determine the relationship between red rot and age in Black Hills ponderosa pine sawtimber. (S. R. Andrews and T. E. Hinds)

62-G-3 Navajo Defect Study

Objective: To determine the importance of red rot in residual ponderosa pine stands cut according to the light improvement selection method. (P. C. Lightle)

62-G-4 Decay in advanced balsam regeneration in the Prince George area of British Columbia.

Objectives: To determine the volume of decay in small balsam (Abies lasiocarpa) which remains after logging of western white spruce-balsam stands, and to use this information to help evaluate the practice of allowing balsam advanced regeneration to become part of the new stand. (R. B. Smith and H. M. Craig)

62-G-5 Decay in young grand fir.

Objective: To study the role of various infection courts in the establishment of decay in grand fir (Abies grandis) and to determine the earliest age of infection. This information will be used to establish silvicultural practices and pathological rotations for grand fir stands. (O. C. Maloy.)

62-G-6 Bark Decomposition by four species of Wood Decay Fungi (Lloyd Reesman M.S.U. Graduate Student)

Objective: To determine the rate of decay of inner-bark versus outer-bark of Douglas fir, Larch and Ponderosa pine by Fomes pinicola, Polyporus volvatus, P. abietinus and Stereum sanguinolentum.

H. Stem Diseases - Rusts and Cankers

62-H-1 Life cycles of western conifer rusts (R. S. Peterson).

Objectives: To delimit the occurrence of pine-to-pine transmission in the Cronartium coleosporioides group and other rusts; to determine susceptible tissue and incubation periods for pine, spruce, and fir stem rusts; to establish the host alternation of unconnected rusts.

62-H-2 Taxonomy and identification of native pine-stem Peridermia (R. S. Peterson).

Objectives: To provide accurate descriptions of symptoms and aecial morphology, and, based on these, valid names.

62-H-3 Epidemiology of Cronartium comandrae. I. Dissection plot studies (R. G. Krebill).

Objectives: By dissection of cankers in random plots on several National Forests to obtain estimates of age, duration, and intensity of outbreaks in lodgepole pine.

62-H-4 Effects of broom rusts on fir and spruce (R. S. Peterson).

Objectives: By a paired tree method, to find and evaluate possible effects of Melampsorella caryophyllacearum and Chrysomyxa arctostaphyli on growth of their hosts.

Miscellaneous Studies

62-K-1 The Taxonomy, Comparative Morphology and Ecology of Fungi of Arid Lands. P. D. Keener

62-K-2 Biotaxonomic studies on forest fungi in Alberta.

Objectives: Conduct research on the systematics and life histories of forest fungi of the region, with emphasis on those of proven or suspected disease significance. (R. J. Bourchier).

APPENDIX II

TERMINATED PROJECTS

53-D-6 Phytophthora root rots of Port Orford cedar and Douglas fir. (L. F. Roth) Publication: Papers in press in Jour. of Forestry, Phytopathology and Forest Science. (L. F. Roth)

57-E-2 Needle cast of ponderosa pine in Arizona and New Mexico (S. R. Andrews).

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

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

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

53-G-3 Decay in high elevation tree species of the central Rockies (R. W. Davidson).

57-G-2 Significance of the Heartwood Stains of Lodgepole Pine.

Conclusions: No reduction either in specific gravity or in strength in impact bending was observed, nor was the durability of the wood in stake plot test reduced on account of stain. No further development of decay associated with red stain occurred during service. The causal organisms remained alive for over 4 years but were quickly killed in wood which was steamed.

Average strength values in static bending and in toughness of red stained wood was lower than those of corresponding clear material. Under laboratory test conditions specimens cut from logs exhibiting red stain developed typical advanced decay (Stereum pini, S. sanguinolentum and Fomes pini) and when stain was introduced into previously unstained wood, resistance to subsequent attack by fungi associated with decay of wood in service, was reduced. (H. W. Eades and J. W. Roff.)

57-G-9 The fungus flora of living lodgepole pine and its possible role in decay development (R. J. Bourchier).

Results: (a) A flora of microfungi occurs in the stems of living 20-90 year-old pine, but only two fungi occurred regularly in 20 year-old trees (Aureobasidium pullulans and Tympanis hypopodia); (b) Coryne sarcoides and T. hypopodia limit the growth of Peniophora pseudopini in wood blocks; (c) Retinocyclus abietis seems to enhance the growth of P. pseudo-pini in wood blocks; (d) there was no marked antagonism between P. pseudo-pini and microfungi in Petri-plates or when using cell-free filtrates from liquid cultures; (e) C. sarcoides and T. hypopodia caused significant weight losses in test blocks; (f) the perfect states of the microfungi have not been found in nature. Efforts to produce them in vitro have failed.

Publications: Bourchier, R. J. 1961. Laboratory studies on microfungi isolated from the stems of living lodgepole pine. Can. J. Bot., 39: 1373-1385.

Bourchier, R. J. 1961. Two new imperfect fungi from the heartwood of living lodgepole pine. Can. J. Bot., 39: 1781-1784.

53-H-5 Native rusts of western pines (J. L. Mielke).

57-H-3 Facters associated with juniper mortality in Arizona and New Mexico (W. E. Eslyn).

58-H-1 Gall rust of lodgepole pine (R. S. Peterson).

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

61-H-3 Life cycle of spruce broom rust (R. S. Peterson).

57-J-1 Relative Durability of Western Red Cedar Heartwood under Accelerated Laboratory Test Conditions.

Conclusions - Decay resistance of western red cedar heartwood in the form of shingles was not reduced as a result of kilndrying at temperatures up to

290°F. Analysis of wood following test indicated that naturally-occurring fungicidal extractives were reduced by fungi before decay was apparent in the wood. Change in colour of the wood from straw to brown was associated with a corresponding decrease in decay resistance which was lowest in the pith region. Tan-yellow heartwood which, in shingles, was soft and pliable to handle and appeared rough sawn was least resistant to decay. (H. W. Eades and J. W. Roff.)

53-K-2 A survey of diseases of aspen in the central Rocky Mountain area (R. W. Davidson).

APPENDIX III

NEW OR MODIFIED TECHNIQUES

A COMPACT UNIT FOR HUMIDITY CONTROL

R. F. SCHARPF

The small humidity chamber (demonstrated) is a modification of the systems described by Osborne and Bacon (Plant Physiology 36(3): 309-12, 1961) in which solutions of glycerine and water are used to control relative humidity. The basic change made by the writer was a reduction in the size of the system. The entire system was reduced to a compact unit approximately 12 inches long, 6 inches wide and 6 inches high. The small size of the unit permits a number of them to be placed in temperature control boxes in which both temperature and humidity may be controlled.

The modified system was used to study the effect of relative humidity on the longevity and germination of dwarfmistletoe seeds but could equally as well be used with other plant material such as pollen, fungus spores or small portions of plant tissue.

Relative humidities of glycerine-water solutions at various temperatures were obtained from "Glycerol", Miner and Dalton, 1953, Rheinhold Co., N. Y.

THE USE OF RADIOISOTOPES TO DETERMINE THE EXTENT OF HEART ROT IN STANDING TREES.

OTIS C. MALOY.

A method of determining the extent of a rot column in the same tree at intervals over a period of time would provide a means for studying the effects of various factors on the progress of decay under natural conditions. The paper of Bose and Bonet-Maury, Nature (London), 185 (4716): 828-830, 1960, suggests that introducing a radioisotope into the mycelial system of the decay fungus might permit the detection of the limits of the rot column.

One-half to 2.0 millicuries of $Rb^{86}Cl$ in a carrier solution of K_2CO_3 was introduced into sporophores of *Fomes pini* and *Echinodontium tinctorium* on their hosts. The tree was scanned with a Geiger counter in attempt to pick up any activity over background.

Results to date have not been satisfactory but this is probably due to imperfections in technique rather than in the validity of the method.

PLASTIC LAMINATING OF FRAGILE PLANTS

J. A. BARANYAY

A method has been developed to protect illustrative specimens of fragile plant material used for reference in the field. The equipment needed is a photo-mounting press that can be heated to about 250°F, and a roll of laminating plastic. The plant specimen should be dried in a conventional press, and mounted on standard herbarium mounting board with short pieces of transparent tape. Both sides of the mounted specimen are covered with plastic, leaving a 1/2 - inch border at the edges of the mounting board. Both pieces of plastic should be cut to the exact same size. The plastic is temporarily fixed to the mounting board by rubbing it by hand when it is in place. The specimen is placed "face down" on a sheet of foam rubber, and covered with a sheet of clean paper. This "sandwich" is placed in a photo-mounting press that has been heated to 250°F, and is left under very high pressure for about 40 seconds. Maximum pressure is obtained by inserting a board beneath the foam rubber pad.

APPENDIX IV

PUBLICATIONS

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2. ______________ and R. J. Bourchier. 1962. Province of Alberta, Forest Disease Survey. In Ann. Rept. of the Forest Insect and Disease Survey, 1961. Can. Dept. Forestry, For. Ent. and Path. Br., Ottawa.

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17. Gordon, C. C., and O. L. Stein. 1962. The use of tritiated uridine as a marker in studies of fungal life cycles. Radiation 2: 7-9.

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19. Hawksworth, F. G. 1961. Dwarfmistletoes of ponderosa pine. Recent Adv. in Bot. Vol. 2, Sect. 14: 1537-1541.

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21. ______________ and Andrews, S. R. 1961. Guides for pruning dwarfmistletoe-infected ponderosa pine branches. Rocky Mtn. For. and Range Expt. Sta., Res. Note No. 64. 3 pp.

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APPENDIX V

MINUTES OF THE BUSINESS MEETING

The business meeting was called to order by Chairman Parmeter on schedule, October 19, 1961.

Secretary's Report: It was moved and seconded that the minutes of the previous meeting, as written in the Proceedings of the Ninth W.I.F.D.W.C. be approved. The motion passed by a voice vote.

Treasurer's Report: The Secretary-Treasurer, with the assistance of Bob McMinn, Chairman of the Local Arrangements Committee, gave the following report.

	Debits	Credits
Registration and Banquet		$506.67
Balance from 1961		61.76
Banquet	$392.25	
Registration	64.51	
Transportation	18.00	
	$474.76	
Balance on hand	93.67	
	$568.43	$568.43

It was moved and seconded that the report be accepted. Motion passed.

Report of the Interim Program Chairman: Clancy Gordon, appointed to serve as Interim Program Chairman by Chairman Parmeter at the opening session, found that the report given by his predecessor (Don Graham) last year had pretty well covered the field. Several of the members contacted referred to it. New ideas submitted to Clancy are contained in Appendix VI.

Mistletoe Committee Report: The committee's report (previously circulated to the membership) is Appendix VII hereto. Additions, deletions and corrections were requested. None being offered, it was moved, seconded and passed that the report be accepted.

Other Committee Reports: None.

Old Business: Difficulties in keeping the membership list accurate and up-to-date were mentioned. The Chairman and the Secretary-Treasurer requested that each member assist by providing addresses of individuals whose names should be added to the roster. Similarly, the Secretary-Treasurer should be informed of any deletions.

The status of graduate students in W.I.F.D.W.C. was discussed. It was the consensus of opinion that graduate students in Forest Pathology are active participants, and thus members from the time that they start their graduate work until they leave the area. It was moved and seconded that, graduate students attending W.I.F.D.W.C. who are not on a per diem basis be charged no registration fee. Attendance at the banquet for graduate students is to be optional. If they desire to attend, the cost of the banquet shall be collected at the time of registration. Motion passed.

Ray Foster, our Historian, offered to prepare an index to the first ten volumes of W.I.F.D.W.C.'s Prodeedings. He requested that any correspondence pertaining to the past history of the organization be forwarded to him. Negatives of group pictures, and extra copies of past issues of the proceedings were also requested.

New Business: The Secretary-Treasurer read a memo from H. R. Offord concerning the hazards from native trees in parks and recreational areas. Offord suggested that a work committee be created to consider the role of Forest Pathology in recreation. Offord suggested Willis Wegener as the logical chairman for such a committee. Wegener objected to the latter suggestion by Offord, stating that as a retired Forest Pathologist there might be some question as to the status of his membership in W.I.F.D.W.C. By unamimous acclamation, Dr. Willis Wegener was immediately elected to emeritus ~~lifetime~~ membership. Wegener then suggested H. R. Offord as the chairman of the proposed committee. Toby Childs commented that the hazards in recreational areas are a very real problem in the Northwest, and that those who do not have such problems at present, certainly soon will! Don Graham reported that the Regional Attorney from his office had given an interesting talk on court cases orginating from Forest hazards. A work committee might help to establish guide lines for the recognition and removal of such hazards. The Forest Service is just getting into recreational research at the present time.

It was moved by Kimmey and seconded that a committee on hazards in recreational areas be appointed. The motion passed. Chairman Parmeter, directed the new General Chairman to appoint this committee.

Place of the 11th. meeting of the W.I.F.D.W.C. Lowell Farmer, requested five minutes in which to justify his invitation that the group meet at Jackson Hole, Wyoming. One half hour later, Mr. Farmer yielded the floor to Paul Kiener who invited the group to Tucson, Arizona where, "there is better weather and less wind." On a show of hands, Jackson Hole was selected as our next meeting site by a clear majority. It was suggested that our meetings be held shortly after Labor Day (week of September 9-13?).

Nominations for Officers: Gardner Shaw was nominated as General Chairman. It was moved, seconded and passed that the nominations be closed. Jack Bier was nominated as Secretary-Treasurer. It was moved and seconded that the nominations be closed. Motion passed.

Adjournment: The motion for adjournment was met by mass migration by those in a hurry to check out of hotels, catch ferrys, planes and the like.

APPENDIX VI

REPORT OF THE INTERIM PROGRAM CHAIRMAN

1. A panel discussion on the present status of antibiotics in the control of Cronartium ribicola and other forest pathogens. (A panel composed of Moss, Hartman, Weir, and S. O. Graham is suggested.)

2. A panel discussion on the status and needs of research on Rust Diseases. (A panel composed of Peterson, Ziller, Moss, Krebel, Wagener and Nighswander is suggested).

3. Ontogeny of the Aerial shoots of Arceuthobium (Gordon)

4. Ontogency of various species of Needle Cast Fungi (Gordon)

5. Chemical control of mistletoes (Quick).

As in 1962, the interim program chairman found most of the group somewhat noncommittal, - "hadn't given it much thought". Several members did comment that numerous topics in the long list of sugges tions in the 1962 report should be considered for next year's program.

It was recommended that there be a moderator for each session, and that this individual not himself present a topic. Rather he should lead the discussion, comment briefly on the contribution from each of the other members of the panel, and direct questions from the audience to particular members of the panel.

To accomplish these objectives, it would be necessary to circulate to all members of the panel the material each intended to present. This should make for better continuity within each panel session. It would have the added advantage that each panel member would have his material ready to hand over to the Secretary for inclusion in the Proceedings!

C. C. Gordon
"Pro tem" Program Chairman

COMMITTEE REPORT ON STATUS AND NEEDS OF RESEARCH ON DWARFMISTLETOES

J. A. BARANYAY, J. R. PARMETER, JR., K. R. SHEA,

and F. G. HAWKSWORTH (Chairman)

Highlights of 1962 Research

I. Taxonomy, Hosts, and Distribution

a. Observations in California showed that *Arceuthobium campylopodum* f. *abietinum* growing on white fir occasionally infects sugar pine in mixed stands where white fir is heavily infected. The association appears to be an incompatible one since relatively few parasite shoots develop. Also, pronounced swelling of the infected portion of the branch occurs. (Scharpf, PSW, Parmeter, Univ. of Calif., Berkeley)

b. Ray Foster has turned over his host specificity studies to me. We both feel that methods of germination have to be developed before going much further. Ray had poor results from seeds collected last fall. I have confined collections to British Columbia and am following methods of Scharpf and Parmeter (J. Forestry 60: 551-552). (R. B. Smith, Victoria)

c. *Arceuthobium campylopodum* f. *laricis* normally occurring on western larch (*Larix occidentalis*) was found infecting lodgepole pine (*Pinus contorta*), ponderosa pine (*P. ponderosa*), subalpine fir (*Abies lasiocarpa*) and Engelmann spruce (*Picea engelmannii*) in the Sherman Creek Drainage, Colville National Forest. This same forma was also found on Norway spruce (*Picea abies*) and red pine (*Pinus resinosa*) on the Priest River Experimental Forest. (Wicker, INT)

d. *Arceuthobium douglasii* has been found in Teton and Lincoln Counties in western Wyoming. These are the first records of the Douglas-fir dwarfmistletoe from Wyoming. (R. S. Peterson, INT)

e. The U.S. Forest Service has given a cooperative aid grant to the University of Colorado for a cytotaxonomic study of *Arceuthobium* of the Southwestern and Rocky Mountain areas. Initial attention will be given to chromosome analyses of the *A. campylopodum* and *A. vaginatum* complexes. (Del Wiens, Univ. of Colo.)

f. The dwarfmistletoe that attacks *Pinus chihuahuana* in Arizona was found to be an undescribed species and not *Arceuthobium vaginatum* as previously thought. The new species differs from *A. vaginatum* not only in the hosts attacked but also morphologically and phenologically. A description of this new species is in preparation. (Del Wiens, Univ. of Colo., and Hawksworth, RM)

g. A mistletoe herbarium has been established at Fort Collins, Colorado. Most of Hedgcock's collections from the old Forest Pathology Herbarium in Washington, and Gill's collections (in Albuquerque) have been or will be filed at the new herbarium in Fort Collins. The collection consists of nearly 1,000 specimens, about two-thirds of which are *Arceuthobium*. Any mistletoe collections for deposit in this new herbarium would be greatly appreciated. (Hawksworth, RM)

II. Physiology and Anatomy

a. Field studies on the translocation of naturally occurring compounds were conducted on white fir (*Abies concolor*) infected with dwarf mistletoe (*Arceuthobium campylopodum* form *abietinum*) by applying $C^{14}O_2$ to the leaves of infected branches. Results indicate that the endophytic system of the mistletoe constitutes an area of marked concentration of photosynthate during all seasons of the year. The region of the endophytic system accumulates three to four times as much radioactivity (expressed on a per unit weight basis) as does the uninfected portions of the host stem. During the dormant season over 90 percent of this radioactivity remains in an ethanol soluble form while in the spring and early summer over 50 percent is unextractable with 80 percent ethanol two weeks after treatment with $C^{14}O_2$. During the growing season the aerial shoots accumulate two to three times more radioactivity than the endophytic system. In contrast during the fall and winter months the endophytic system absorbs about five times more photosynthate than do the aerial shoots. The concentration of radioactivity in the host stem below the infected region is often equal to that of uninfected stem tissue above the site of infection although this is subject to considerable variation.

When phosphorus-32 (as the phosphate) and sulfur-35 (as the sulfate) were applied to the bark of the host stem either above or below the site of infection marked accumulation was observed in the endophytic system and aerial shoots of the mistletoe. It seems likely therefore that the mistletoe is capable of extracting these anions from both the xylem and phloem of the host plant. These studies were conducted largely on *Pinus sabiniana* infected with *Arceuthobium campylopodum*.

Chlorophyll determinations were made on the aerial shoots of a variety of dwarfmistletoes (A. americanum; A. campylopodum forms divaricatum and abietinum). Both chlorophyll a and chlorophyll b were detected in all samples tested. The total chlorophyll content varied from 0.01 to 0.05 percent of the shoot dry wieght compared with concentrations of 0.1 to 0.15 percent of the dry weight of conifer leaves. The ratio of chlorophyll a to chlorophyll b in the mistletoe shoots was variable but averaged about 2.0 while that for conifer leaves was about 3.75.

When aerial shoots of the dwarf mistletoe (A. americanum or A. campylopodum) were exposed to $C^{14}O_2$ in the light, marked fixation of the labelled carbon was observed. The radioactivity, however, was never observed to translocate basipetally into the endophytic system nor into the host plant. Similar studies were conducted during all phases of the growing season (early spring through late fall) on both male and female plants but movement of radioactivity out of the aerial shoots has yet to be observed. Defoliation of the infected branch, covering its leaves with aluminum foil or isolating the site of infection by means of girdles all failed to promote movement of photosynthate out of the aerial shoots. These findings are in agreement with anatomical studies which have failed to demonstrate any phloem tissue in shoots of Arceuthobium.

By way of comparison, similar studies were conducted on the true mistletoe infecting a variety of host plants (Phoradendron juniperinum var. ligatum on Juniperus occidentalis; P. juniperinum var. libocedri on Libocedrus decurrens; P. bolleanum var. densum on Cupressus macnabiana; P. bolleanum var. pauciflorum on Abies concolor; P. flavescens var villosum on Quercus kelloggii, Q. wislizenii and Q. douglasii; and P. flavescens var. macrophyllum on Juglans hindsii). In every case when $C^{14}O_2$ was applied to the leaves of the host plant the label translocated basipetally through the site of infection with no radioactivity accumulating either in the endophytic system or the aerial shoots of the mistletoe. When mistletoe shoots were treated with $C^{14}O_2$ marked fixation was observed accompanied by translocation into the endophytic system during certain seasons of the year but very little if any radioactivity moved into the host plant. This confirms the widely held belief that Phoradendron is a true water-parasite. Arceuthobium, on the other hand, would appear to depend heavily upon its host not only for water and minerals but also for carbohydrates.

Studies were conducted with carbon-14 labelled 2,4-dichlorophenoxyacetic acid, 2,4,5-trichlorophenoxyacetic acid and urea. Very little 2,4-D or 2,4,5-T penetrated the conifers through the leaves or bark, however, appreciable quantities were translocated through the branches when the applications were made to cuts. Urea was absorbed fairly well by the aerial shoots of the dwarf mistletoe when such shoots were kept covered with a polyethylene bag (to maintain a high relative humidity which facilitates absorption). (R. J. Hull and O. A. Leonard, Univ. of Calif., Davis)

b. With a view to finding a metabolic system in the mistletoe capable of being attacked by a herbicide, a study was conducted of the amino acid content of the dwarf mistletoe and that of its hosts. The method used was two-dimensional chromatography of purified extracts of the free amino acids or of those liberated on hydrolysis of proteins.

Little difference was found in the amino acids of the mistletoe (or its endophytic system) and those of the host plants. If an amino acid was not present in both in the free form, it was usually present in the bound. However, free hydroxy-L-proline was found in the dwarf mistletoe shoots and their endophytic system but occurred only in the bound form in the host tissue. The occurrence of free hydroxyproline is very rare in plants and its biosynthesis is not well understood. It is suggested that an analogue of hydroxyproline, e.g., a sulfonic acid analogue, could be used as a selective poison for dwarf mistletoe, applied by means of trunk injections.

On comparing the amino acids of white fir and red fir, it was noted that in the former no tryptophan and asparagine were found, whereas in the latter asparagine and traces of tryptophan were detected. This difference, if real, might possibly explain why the mistletoe infecting red fir is not found on white fir but not why that on white fir does not attack red fir. (C. G. Greenham, Univ. of Calif., Davis, now at the CSIRO, Plant Industry Division, Canberra, Australia)

c. The relative turgidities of bark were measured on 31 mistletoe infected western hemlock branches during the spring to detect possible bark moisture differences through the swollen portion of each branch. Examination of the data revealed a different moisture pattern in branches infected for less than 10 years than in those infected for over 10 years. In the young infection group moisture content of bark was highest at the center of the infections and decreased towards the ends of infections. In the old infection group the moisture content of the bark was highest at both tips of the swellings while the moisture content in the center was similar to that of the uninvaded area. (J. A. Baranyay, Calgary)

d. Work was begun on the extraction of growth regulators from dwarfmistletoe plants and from infected host tissue (host-parasite combination). Using paper chromatograms, three possible growth regulating compounds have been recovered from the infected host tissue and two from the dwarfmistletoe plants, both of which appear to be identical with two of the compounds recovered from infected tissue. This work will continue and an attempt will be made to purify and identify these compounds and to test their biological activity via bioassay, electrophoretic, and spectrophotometric techniques. (Wicker, W.S.U.)

III. Life Cycle Studies

a. A rapid viability test using H_2O_2 has been worked out for testing dwarfmistletoe seed which had been stored in the laboratory. This test results in direct germination of seed within a three- to eight-day period. Abstract in Phytopathology, August, 1962. (Wicker, W.S.U.)

b. Seedlings of the coast form Douglas-fir have been infected with A. douglasii in greenhouse inoculations. Symptoms and development of the parasite appear to be no different than infected mountain form Douglas-fir and there appears to be no difference between susceptibility of the two host forms. (Wicker, W.S.U.)

c. Stem infections repeatedly prove fatal to western larch seedlings under 6 years old. Mortality from stem infection has also been observed to occur in nature where seedlings were 10-12 years old. (Wicker, W.S.U.)

d. Field inoculations show that a very high percentage of the dwarfmistletoe seed are removed from seedlings by winter snow and spring rains. (Wicker, INT)

e. Studies of seed storage, viability and germination indicate that the seed are favored by low temperatures (1° to 5° C.) and that they are short-lived. (Wicker, INT)

f. The expulsion of seed from the fruit of Arceuthobium has been successfully photographed using a speed of 5 microseconds. Black and white and color photographs will be shown at the Victoria meeting. (T. E. Hinds, RM)

g.. The flowering periods of two mistletoes (A. americanum and A. vaginatum f. cryptopodum) were studied in one locality in northern Colorado. Weekly counts of flower opening and of pollen dispersal on vaselined slides were made. For A. americanum pollen dispersal occurred from April 11 to June 13 with about 90 percent of the pollen caught during the 3-week period from April 18 to May 9. For A. vaginatum f. cryptopodum pollen dispersal occurred from May 9 to August 8 with about 90 percent of the pollen caught during the 5-week period from May 23 to June 27. (Hawksworth and Hinds, RM)

h. Studies on the interception, movement, and germination of naturally dispersed Arceuthobium seeds were continued. Some interim findings are tabulated below. The total number of seeds produced is taken as 100 percent.

	Arc. vaginatum on Ponderosa pine	Arc. americanum on Lodgepole pine
	Percent	Percent
Seeds intercepted by trees	44	38
Seeds on twigs, October of first year	10.1	17.1
Seeds germinated on twigs, October of second year	3.8	10.7
Seeds germinated on twigs October of third year	1.2	4.8

Thus, the number of seeds which are in position to cause infection is 4 times as great in A. americanum as in A. vaginatum. Several hundred seeds from 4 years' crops are being followed through to infection. Also, chronological development of young infections will be observed. (Hawksworth, RM)

i. A study to attempt to learn why some trees are not infected by certain species of dwarfmistletoe has been started. Preliminary results have indicated at least two causes for non-infection: (1) the radicles may not form hold-fasts (as in A. vaginatum on Pinus flexilis), or (2) hold-fasts may be formed but a hypersensitive host reaction results in a necrotic spot that prevents establishment (as in A. americanum on Abies lasiocarpa). (Hawksworth, RM)

j. Ontogeny of the aerial shoots of A. douglasii and A. campylopodium f. laricis

Objective: To follow the morphological and cytological development of the above dwarf mistletoes from the time the aerial shoots erupt through the bark to pollen or seed production. (Bill Jones, M.S.U. Grad. Student)

k. Ponderosa pine seedlings from the Black Hills of South Dakota have been infected by Arceuthobium vaginatum in greenhouse inoculations. The pines from the Black Hills appear to be as susceptible as those from several sources within the range of the dwarfmistletoe. (Hawksworth, RM)

IV. Host-Parasite Relations

a. We have continued on a small scale our studies of ponderosa pine mistletoe intensification. Work this year, together with preliminary analyses of the growth reduction data, substantiate previous conclusions that intensification is rather rapid. Mature trees that are now heavily infected, and suffering proportionate reduction in annual increment, appear to have been thriving about 40 years ago. Dissections of the trees, with determinations of the ages of all infections, also strongly indicate that numbers of infections increase much more rapidly under ordinary conditions than does size of target. (Childs, PNW).

b. The data from a growth study of A. americanum in immature lodgepole pine, based on over 6,000 trees on about 130 plots, have been analysed for information on population dynamics. The inter-relationships of average plot dwarfmistletoe rating, length of time infected, and percent of trees infected have been determined. Percent of trees infected, the most easily measured of these factors, can be used to estimate time infected, which in turn is most directly related to the degree of damage caused by dwarfmistletoe. (Hawksworth, RM)

V. Effects on Hosts (Damage, Mortality)

a. Field work on the growth reduction phase of the ponderosa pine mistletoe impact study has been almost completed unless, as seems very unlikely, we find another good study area. Results from this phase of the study will not be available for at least several months, and it will probably be more than a year before we can complete automatic data processing. Our mortality figures are still far from adequate, and we hope to get considerable additional data on this point. (Childs, PNW)

b. A very general survey of dwarfmistletoe in B.C. was made during a three-week period this summer. The main objective of the survey was to determine what tree species were most seriously affected and shouldreceive prior attention. In addition, areas suitable for future studies were noted.

Four host-parasite relationships were observed as being most important: Arceuthobium campylopodum on western hemlock (coastal areas of B.C. only); A. campylopodum on western larch (restricted, because of host range, to southern interior of province); A. americanum on lodgepole pine; and A. douglasii on Douglas-fir (southern interior of province only). Some infections of western white pine by A. campylopodum, and of lodgepole pine also by A. campylopodum, were found occasionally in the southern interior of B.C.

A. douglasii, while spectacular in its effect, appears restricted in B.C. to extremely dry and rocky sites, and its economic importance does not appear near that of the other three. The Calgary, Alberta, laboratory is considering aspects of A. americanum parasitism, and so I'll probably not initiate any growth studies on that species. Thus, A. campylopodum on western larch and on western hemlock will receive most attention in the area of growth studies. (R. B. Smith, Victoria)

c. A study has been started to determine the effects of A. vaginatum f. cryptopodum on growth and yields of ponderosa pine stands in Arizona, New Mexico, and Colorado. The method used is to locate infected and healthy areas of even-aged stands on uniform sites. Transects are then established to determine tree sizes and stand volumes in relation to amount of infection. Data were obtained on 19 transects with more than 2,000 trees during the first summer. Analyses of the data have not been started. It is anticipated that one or two more summers' work will be needed to complete the study. (Lightle, Hinds, and Hawksworth, RM)

d. Dwarf mistletoe and its effect on growth and mortality in lodgepole pine stands of Alberta. Field work was completed but data have not been completely analyzed. (J. A. Baranyay, Calgary)

VI. Ecology

Field work has been completed on a study on the relationship of Arceuthobium vaginatum on ponderosa pine to soil types on the Manitou Experimental Forest, Colorado. The data have not been completely analysed but there seem to be statistically significant differences in frequency and abundance of the parasite on the 3 soil types sampled. Dwarfmistletoe was found on 32 percent of the plots on soils derived from granite. Comparable figures for limestone and arkose soils were 43 and 59 percent, respectively. The limestone soils are most productive and granite soils the least productive, as determined by average ponderosa pine site index in mistletoe-free dominants. (Hawksworth, RM)

VII. Control - Chemical

a. Experimentation aimed at direct chemical control of dwarfmistletoe on pines and true firs in California has continued. Some 40 tests (570 trees) were initiated in 1962. Benzac (a chlorinated benzoic acid) and Fenac (a chlorinated phenylacetic acid) were used on dwarfmistletoe in California for the first time. Several of the phenoxy herbicides were applied in oil-soluble amine formulations. Additional tests with the isooctyl esters of 2,4-DA and 2,4,5-TB were started. (Quick, PSW)

b. The many 1959-1961 tests aimed at direct chemical control of dwarfmistletoe on pines and true firs in California were inspected in 1962 in some detail. Some cankers directly sprayed in 1959 still appear to be dead; a few others so treated look as if they might sprout anew in 1963. At the present time, 2,4,5-TB and 4-CDA apparently offer best chances of somewhat systemic treatments of dwarfmistletoe on pines. Proven materials and methods for successful control of directly sprayed infestations of dwarfmistletoe on pines should be available by 1963 to 1965. (Quick, PSW)

VIII. Control - Biological
(no reports)

IX. Control - Silvicultural

a. Forest Economics Research in this Station has completed the field work on costs of control under various conditions. Their data indicate that control can be obtained at quite reasonable costs under favorable conditions, but their final results will not be available until it is possible to combine them with results of the impact study. (Childs, PNW)

b. A plot study of the effects of three degrees of dwarfmistletoe eradication combined with four degrees of silvicultural thinnings on intensification, spread and adverse tree growth impact was established on the Colville National Forest. Cost data were obtained on all treatments. (Wicker, INT)

c. Dwarfmistletoe control on the Mescalero Apache Indian Reservation, Whitetail Unit is progressing. During the first $1\frac{1}{4}$ years of the first recleaning, infected merchantable trees were left standing because of the possibility of selling them. No sale was consummated due to the depressed market and so the trees are being felled. All such merchantable trees should be on the ground by the end of this month. In the future, all infected merchantable trees will be dropped at the same time as the submerchantable. With $1\frac{1}{2}$ years of recleaning gone, about 3/5 of the total area has been covered. (Lightle, RM)

d. A 29-year examination was made on a silvicultural control (Hatfield) plot on the Fort Valley Experimental Forest, Arizona. This 12-acre plot is in a heavily infected stand that had all visible dwarfmistletoe removed in 1933 and in 1938. There has been no treatment since 1938. A progress report on this plot up to 1951 is given in the Journal of Forestry 52:348, 1954. The 1962 examination showed that there has been about a 20 percent increase in number of infections since 1951 but that the number of infected trees remained about the same:

	1951	1962
Number of infected trees per acre	10.2	10.5
Number of infections per acre	33	39

This mistletoe population is still too small to have a significant effect on the growth of ponderosa pine in the plot. (Lightle and Hawksworth, RM)

X. Surveys

a. Lodgepole pine dwarfmistletoe is one of the most serious enemies of lodgepole pine in the Central Rocky Mountains. In order to begin a control program to eradicate this forest pest, we first have to know the location of infected stands, size of infected area and type of stand infected. We can then decide which type of silviculture control method will best accomplish the job.

In 1961, we began surveys on the Red Feather District, Roosevelt National Forest. To date, survey crews have covered approximately 34,000 acres of lodgepole pine type. All of the area has been surveyed at 5 percent intensity (parallel cruise lines spaced ten chains apart) using the continuous one-half chain wide strip method. Data was tallied by four-chain transects along the lines. From the survey data we were able to plot, on large scale photo mosaics, the location and the boundaries between infected and non-infected stands. We now know the type of stands infected (sawtimber, poles, reproduction), ground conditions, percent of slope, and density of stocking. This information will be valuable to us in writing pre-sale prescriptions, determining the cutting patterns of future sales and will aid us in planning timber stand improvement projects. Cost of the survey was about $.10 per acre.

It is our objective that dwarfmistletoe surveys will precede the preparation of pre-sale prescriptions for all future lodgepole pine sales. This will enable us to give top priority to logging the infected stands. (A. E. Landgraf, USFS, Region 2, Denver)

b. Field surveyed stands of dwarfmistletoe infected lodgepole pine stands will be photographed with a Vinten 70 mm. camera at various scales and focal lengths and with various film and filter combinations late in September to explore whether aerial photography will enable the detection of infected areas.

Preliminary photography with infrared film gave promising results. (J. A. Baranyay, Calgary)

Needed Research

III. Life Cycle

a. Research is needed to assess the importance, as centers of infection, of suppressed understory western hemlock after clear-cutting. The importance of light in the initiation of aerial shoots on such suppressed trees should also be investigated. (R. B. Smith, Victoria)

b. A major obstacle in artificial inoculations is a technique which will result in a high percentage of infections. More work needed on this technique. (Wicker, W.S.U.)

V. Effects on Hosts (Damage, Mortality)

Research is needed to demonstrate loss in increment and mortality caused by dwarfmistletoe on western larch and western hemlock in B.C. Methods of Duff and Nolan (Can. J. Bot. 31: 471-513) should be useful here. Side effects, such as the entrance of decay-causing organisms through infections, should also be studied. (R. B. Smith, Victoria)

APPENDIX VIII

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and guests at the Tenth Conference

(* indicates members and ** indicates guests present at the Tenth Conference)

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APPENDIX IX

SUMMARY OF EXPERIMENTS ON DIRECT CHEMICAL CONTROL OF SOME FOREST DISEASES IN WESTERN NORTH AMERICA

By C. R. Quick, et al.

FOREWORD

Proceedings of the Third Western International Forest Disease Work Conference (1955, pp. 18-25) contain Lake Gill's report "Summary of Chemicals Tested for Controlling Western Species of Dwarfmistletoe (Arceuthobium spp.)." Heightened interest in chemical control of dwarfmistletoe and other forest diseases has stimulated a great many tests since Gill prepared his summary. New chemicals have become available, and new methods have been developed. A suggestion was made in 1960 or 1961 that Gill's summary be brought up to date. In the business meeting of W.I.F.D.W.C. at Banff, October 1961, the project suddenly "ballooned" to include all forest diseases in western North America for which chemical control data were available.

In accordance with the directive of the Banff conference (Proc. 9th W.I.F.D.W.C., pp. 75-76), J. R. Parmeter, 1962 Chairman of the Conference, after consultation with F. G. Hawksworth, 1962 Chairman of the Mistletoe Committee, appointed a committee to compile the desired information. The membership of this committee is George M. Harvey, Virgil D. Moss, Clarence R. Quick (Chairman), and Keith R. Shea. Summarization of all experimental chemical control work is attempted herewith. Subject matter for the report was divided into 15 units. One man was asked to collect available data for each unit. The 15 units are carried as major headings in the report.

The idea of a summary perhaps was a little premature for many of the 15 units. Many tests on many diseases have been initiated in the last four to six years, but chemical control tests mature slowly and few positive statements about control can yet be made for most of the diseases. We hope this compilation will summarize leads and trends, prevent unnecessary duplication of work, and hasten development of successful and economic chemical control of various forest diseases.

Fungicidal control of blister rust on western white pine with antibiotics in northern Idaho and adjacent areas has matured to the extent of a dozen or so publications. Because materials, methods, and results have been published and are no longer considered experimental, this unit has been reduced in the summary to little more than a list of literature citations. Chemical control of root diseases in forest nurseries has been excluded from the unit on root diseases for a similar reason. Nursery problems in their character and solution tend strongly to be local. In this field also there are a number of publications.

Because of the broadness of the assignment, we have tried to condense the unit summaries as much as plausible. By no means are all known tests reported. Names of workers are cited consistently so that correspondence, if stimulated, may be accurately directed. No general bibliography is offered; within the units in many instances selected citations replace full listings of publications. Use of trade names is common but is not in any sense an endorsement of named products nor is criticism implied of similar products which are not mentioned.

Spray carriers and methods of application should not be taken for granted. Ultimately they may be as important to effective disease control and to minimization of host damage as the chemicals and concentrations employed.

Different methods and intensities of reporting, summarizing, and condensing experimental data are obvious in the various units. Tabular summarization was tried but was found in general to be discouragingly bulky. Any simple series of well planned tests tends to have an amazing array of variables which often fits poorly into tightly condensed tables.

A new compilation of herbicide names and abbreviations has been published since the committee's call for data went out in the spring. We will follow this list in general (Shaw, Wilbur C. (Chairman)--Report of the Terminology Committee, Weed Society of America, Weeds 10(3): 255-271, 1962). We have departed in at least two respects from this compilation; e.g., we use 24-DA instead of 2,4-D for 2,4-dichlorophenoxyacetic acid. We have omitted the comma in the numerals, and we have added the A (for acetic) to standardize with 24-DP (for propionic) and 24-DB (for butyric). Herbicidal esters of phenoxy acids are numerous and often have a sort of chemical company trademark. Thus Dow's esters are commonly PGBEE (propylene glycol butyl ether esters) and Amchem's are BOEE (butyoxyethanol esters). Some other common herbicide esters are IOE (isooctyl) and IPE (isopropyl). There also are water soluble amines, oil soluble amines (O.S.A.), sodium salts, and many other compounds of the phenoxy acids.

Perhaps the minimum of general handbooks for users of experimental pesticides is the following:

Dittmer, Dorothy S. (Editor)--Handbook of Toxicology, Vol. V: Fungicides, 1959, x + 242 pp., W. B. Saunders Co.

Martin, Hubert. Guide to the Chemicals Used in Crop Protection. Research Branch, Canada Dept. Agric., Ed. 4, 1961, 387 pp. + index, Queen's Printer, Ottawa.

Stecher, Paul G. (Editor), The Merck Index of Chemicals and Drugs, Ed. 7, 1960, xii + 1,641 pp., Merck & Co., Inc.

UNIT I. BLISTER RUST ON WESTERN WHITE PINE

V. D. Moss and C. R. Quick, Compilers

Uses of cycloheximide (Acti-dione) and phytoactin (Phyto-Pabst, later Phytoactin) in Idaho and adjacent portions of the western white pine region are no longer considered experimental. Field methods of use have been developed and published. For this reason no attempt is made here to resummarize the great mass of work relating to this unit of the summary. See especially the following publications:

Ziffer, Jack, et al. 1957. Phytopath. 47(9): 539 (Abstr.)
Moss, V. D. 1958. Plant Disease Reporter 41(8): 709-714.
Ford, J. H., et al. 1958. Plant Disease Reporter 42(5): 680-695.
Moss, V. D. 1958. Plant Disease Reporter 42(5): 703-706.
Moss, V. D., et al. 1960. Jour. Forestry 58(9): 691-695.
Lemin, A. J., et al. 1960. Forest Science 6(4): 306-314
Moss, V. D. 1961. Forest Science 7(4): 380-396.
Viche, H. J., et al. 1962. Jour. Forestry 60(11): 782-784.

L. N. Anderson reports that tests were started with cycloheximide (Acti-dione BR Concentrate) at 100, 150, and 200 ppm on 75 western white pine trees on Abbott Creek, Rogue River N. F., Oregon, on May 20, 1959. Treatment was basal spray with hand equipment; carrier was stove oil. Good to excellent control of blister rust was reported, but trees were moderately damaged. Effectiveness of treatment changed little if at all with concentration of fungicide.

D. P. Graham reports a test with phytoactin (Phytoactin L-318) at 286 ppm on some 670 acres of western white pine sprayed by helicopter in 1961 on the Gifford Pinchot National Forest, Washington. Sixty-five sample trees were selected for detailed checking. Carrier was an emulsion of 20 percent stove oil and 80 percent water applied at the rate of 7 gallons/acre. In 1962 moderate to heavy damage was apparent to blister rust infection on the area. Trees were not damaged. Additional tests were started in 1962.

UNIT IIA. BLISTER RUST ON SUGAR PINE IN OREGON

G. M. Harvey, Compiler

L. N. Anderson reports that two series of tests with cycloheximide (Acti-dione BR Concentrate) at 100, 150, and 200 ppm were started on the Rogue River National Forest in 1959. Treatment was basal spray with hand equipment; carrier was stove oil. Some 45 trees were treated on May 20, and 80 trees were similarly treated in early July. Good to excellent control of the rust is reported in both tests. The trees were moderately damaged in the May test but sustained little or no damage in the July tests. Effectiveness of treatment varied little if at all with concentration of fungicide.

L. N. Anderson, also in 1959, started a single test of Acti-dione BR Concentrate at 150 ppm on 260 sugar pine trees on the Rogue River National Forest. Treatment was basal spray with hand equipment; carrier was stove oil (fuel oil No. 1). Moderate to heavy damage is reported to blister rust infection, and light but definite damage to host trees.

D. P. Graham reports that 144 acres of sugar pine were sprayed with Phytoactin L-318 at 286 ppm by helicopter in 1961 on the Rogue River National Forest. Carrier was 20 percent stove oil and 80 percent water. Dosage was 7 gallons/acre. Seventy trees were selected for detailed check. First year inspection showed moderate effects on the disease and no appreciable damage to the sugar pine.

D. P. Graham further reports that 100 acres of sugar pine in southwest Oregon was treated in 1961 and 1962 with Phytoactin L-439 and L-440 in stove oil as basal stem spray with hand equipment. Some 250 trees have been selected for detailed study. Additional tests were started in 1962.

F. A. TerBush reports initiation in 1962 of a large scale test of Phytoactin L-318 at 150 ppm concentrate on sugar pine in the Tiller area, Umpqua National Forest, Oregon. Treatment was overall crown spray from the ground. Carrier was water with emulsified oil.

UNIT IIB. BLISTER RUST ON SUGAR PINE IN CALIFORNIA

C. R. Quick, Compiler

W. V. Showalter and R. W. Gustafson (R-5) report a large number of small tests with conventional fungicides on blister rust on the Klamath National Forest, California, in 1959 and 1960. All tests included basal stem sprays and treatments of infection only. Hand equipment was used in all tests. Infection-only tests were made largely on tree trunks, but sometimes on limbs. Carrier commonly was stove oil (PS No. 100), but sometimes kerosene and occasionally diesel oil.

Moderate to heavy damage to blister rust with no appreciable damage to host trees is reported in general for Brilliant Green (an antiseptic dye) at 500 and 1,000 ppm, Dowicide 1 (o-phenylphenol) at 500 to 2,000 ppm, and Terraclor 2#/Emulsive (PCNB, i.e., pentachloronitrobenzene) at 500 to 2,000 ppm. Moderate to heavy damage to disease with moderate but presumed safe damage to host is reported in general for treatments with Cyprex 65-W (dodine) at 625 to 2,500 ppm, for Dowicide 1 (o-phenylphenol) at 0.75 percent to 1.00 percent (10,000 ppm), and for Glyodin Solution Crag (glyodin) at 500 to 2,000 ppm. No appreciable damage to either disease or host resulted from treatments with benzoic acid at 1,000 ppm; and none from 8-quinolinol-benzoic acid at 500 to 2,000 ppm. Some trees were killed by Terraclor 2#/Emulsive (PCNB) at 0.4 percent (4,000 ppm) to 0.6 percent.

W. V. Showalter and R. W. Gustafson (R-5) also report on a large number of tests with antibiotic fungicides on blister rust on the Klamath National Forest in 1959 and 1960. Methods, carriers, and equipment were the same as for tests with conventional fungicides described above. Moderate to heavy damage to disease with no appreciable damage to host is reported for Phytoactin L-340 at 400 ppm (1960 test). Moderate to heavy damage to disease with moderate but presumed safe damage to host is reported in general for Acti-dione Formulation 97 (cycloheximide) at 60 to 600 ppm, Acti-dione BR Concentrate at 60 to 600 ppm, Phytoactin L-341 at 200 to 550 ppm, Phytoactin L-342 at 500 to 1,000 ppm and Acti-dione BR New Formulation (1961 tests) at 200 and 400 ppm.

C. R. Quick and field assistants initiated some 125 tests (1,625 trees) with many fungicides on blister rust on sugar pine in north central California during the years 1959-1962. Early tests were almost entirely overall crown spray and basal stem spray; later tests were largely treatments of infection only. This change in emphasis paralleled the dimming hope of finding a material and method for satisfactory systemic treatment of sugar pine in this area. Most common principal carrier was stove oil (PS No. 100), but some tests were applied in kerosene, and some in diesel oil.

Solvents and other adjuvants were added rather commonly to the principal carrier.

Several sorts of fungicides have been tested by Quick, usually over a range of concentrations: (1) antibiotic chemotherapeutants (cycloheximide, phytoactin); (2) conventional fungicidal chemotherapeutants (8-quinolinol, Omadine #1439 and #2235, Union Carbide #1182 and #1207); (3) phenolic and cresolic antiseptics (m-cresyloacetate and Dowicides 1, 2, 4, and 7); (4) other simple stable oil-soluble fungicides (benzoic acid, diphenyl, glyodin, thymol); (5) certain potent agricultural fungicides (Cyprex, Dyrene, Terraclor), and a few "long shots" (Brilliant Green, an antiseptic dye), 2-mercaptobenzothiazole (a rubber vulcanization accelerator—and fungicide) and zephiran chloride (a potent antiviral agent). About 30 percent of all tests involved antibiotics.

Fungicidal tests on blister rust on sugar pine don't seem to "bear up" very well. They'll look good for a year or two and then apparently deteriorate. Many tests in the program are too recent to give final results; we'll know a lot more in a couple of years. We have seen systemic chemotherapeutant effects on sugar pine, but such results seem to have been erratically distributed through the program and are not yet precisely predictable. Within a year or two we hope to be able to prescribe a chemical, concentration, carrier, and method for the satisfactory direct treatment of blister rust infection on sugar pine in our area.

The most promising data from tests started in 1959 were from one treatment with Phyto-Pabst L-317 at 150 ppm and one with Phyto-Pabst L-319 at 400 ppm. Both were applied in creek water as overall crown spray.

The 1960 tests (32 tests/354 trees) in Quick's series were applied to an area of heavy but old blister rust infection. About 30 percent of all treated trees died, perhaps because of excessive blister rust in the bark. Most effective conventional fungicides applied in 1960 (1962 check) were: (1) Cresatin (m-cresyl acetate), 1 percent in stove oil carrier; (2) Dowicide 1 (o-phenylphenol), 1 percent in stove oil; (3) isopropyl benzoate (0.5 percent) and 24-DA (2,000 ppm) in kerosene; and (4) Terraclor 2# Emulsive (pentachloronitrobenzene), 1 percent in stove oil. Most effective antibiotic tests in this series (1962 check) were (1) Phytoactin L-342 at 1,010 ppm in isopropanol, (2) Phytoactin L-341 at 400 ppm in isopropanol (1,160 ml.) and diesel oil (840 ml.), (3) Actidione BR Concentrate at 600 ppm in stove oil (1922 ml.) and technical grade cyclohexanone (47 ml., about 2.2 percent). The best conventional fungicides applied in 1960 appear to have the edge over antibiotics for direct treatment. No clear-cut advantage of antibiotics over conventionals is apparent in tests of attempted systemic control.

Quick's 1961 series consisted of 54 tests on about 850 trees. Stove oil was the commonly used carrier. Most promising materials (1962 check), as far as apparent systemic effects were concerned, were (1) Dowicide 1 at 2.5 percent, (2) Cresatin at 1.5 percent, (3) Glyoxide 70-W (glyodin) at 2.0 percent, and (4) Glyodin Solution Crag (glyodin) at 2.0 percent. Many materials promise good direct effectiveness. Mertax (2-mercaptobenzothiazole) at 0.5 percent, and Union Carbide #1182 at 2.0 percent apparently killed all cankers to which directly applied.

Quick's 1962 series (20 tests/250 trees) on blister rust in north-central California consisted largely of higher concentrations of conventional fungicides previously tested and first trials of some additional conventionals. Acti-dione BR New Formulation was applied (at 400, 500, and 600 ppm in stove oil and diesel oil) for the first time.

An office report--Fungicidal Control of Blister Rust on Sugar Pine in California, Progress Report, 1962, C. R. Quick--was issued in late November, 1962. Anyone wishing to study in detail the progress of that portion of this work supervised by the PSW Station should borrow a copy of the cited report. Persons who were furnished copies of this report include: W. V. Benedict and C. P. Wessela, Roy Blomstrom and N. J. MacGregor, T. W. Childs and G. M. Harvey, R. W. Gustafson and W. V. Showalter, J. R. Hansbrough and T. S. Buchanan, Ben Howard and D. P. Graham, J. W. Kimmey and J. W. Koenigs, V. D. Moss, H. R. Offord, J. R. Parmeter, and C. R. Quick.

UNIT III. BLISTER RUST ON HIGH ALTITUDE WHITE PINES

V. D. Moss, Compiler

Pines included here are *Pinus albicaulis* (whitebark), *P. aristata* (bristle cone), *P. balfouriana* (foxtail), and *P. flexilis* (limber pine).

Several tests have been established on limber pine and whitebark pine by the D&I (Spokane) Unit, U. S. Forest Service, Region 1, but reliable results will not be available before 1963 inspection.

D. P. Graham reports a test of cycloheximide (Acti-dione BR Concentration) at 150 ppm started on 100 whitebark pines in Mt. Ranier National Park, Washington, in 1961. Hand equipment was used; treatment was basal spray. Carrier was stove oil (fuel oil No. 1) to which 0.3 percent of Triton B-1956 had been added as an adjuvant. In 1962 the test held promise of moderate effectiveness on the disease with light but some definite damage to tree hosts.

UNIT IV. STEM RUSTS OF CONIFERS, EXCLUSIVE OF CRONARTIUM RIBICOLA AND PERIDERMIUM HARKNESSII

G. M. Harvey, Compiler

J. W. Koenigs reports initiation in 1961 of a series of nine aerial spray tests of cycloheximide derivatives applied in oil-water emulsion to Cronartium comandrae on lodgepole pine near Red Lodge, Montana. Treatments included a check (no treatment) and a spray with oil-water emulsion (10 gallons/acre) only. Cycloheximide semicarbazone at 200, 300, and 400 ppm was applied at 5 and 10 gallons/acre, and cycloheximide methylhydrazone at 300 ppm was applied at 5 gallons/acre. No curative effects and no damaged trees were noted in 1962.

J. W. Koenigs put out a second series of four tests with cycloheximide derivatives with hand equipment on the same species at the same time and place. In these tests the carrier was fuel oil No. 1, and the treatment was basal stem spray. A no-treatment check and a fuel-oil-only treatment were included. Cycloheximide semicarbazone at 300 ppm and cycloheximide methylhydrazone at 300 ppm completed the series. Results were the same as in the aerial spray series—no host damage and no curative effects apparent in 1962.

UNIT V. WESTERN GALL RUST (PERIDERMIUM HARKNESSII MOORE)

C. R. Quick, Compiler

E. F. Wicker and C. D. Leaphart (Plant Disease Reporter 45(9): 722-724, 1961) report no control of Peridermium harknessii on lodgepole and ponderosa pine from helicopter spray (10 gallons/acre) of 10-acre test blocks near Bovill and Clarkia, Idaho, in early June 1959. Materials were (1) phytoactin at 100, 200, and 400 ppm in water only, (2) cycloheximide at 100 ppm in 20 percent oil-water emulsion, and (3) cycloheximide semicarbazone at 100, 200, and 400 ppm, in 20 percent oil-water emulsion.

R. S. Peterson in 1960 started a series of tests on western gall rust on lodgepole pine (Roosevelt National Forest, Colorado) and on ponderosa pine (Black Hills National Forest, South Dakota). All tests, each of 25 trees, were basal stem applications in fuel oil No. 1. Phytoactin, cycloheximide, and four cycloheximide derivatives were applied at 200 ppm concentration. Fuel-oil-only treatment and a no-treatment check completed each test series. In correspondence Peterson offers the following comments on the tests: ". . . inspection in 1962 showed that the rust infected tissue (rust plus host) had died when sprayed directly, but this was true also in checks with the fuel oil carrier; untreated checks were sporulating as before the test. There was no evidence of translocation. Results are therefore regarded as negative."

C. R. Quick in September, 1961 started ten small tests on gall rust on ponderosa pine saplings along upper Concow Creek, Butte Co., California. Materials were applied with a pump-up garden sprayer in stove oil carrier. First year checks indicate some promise of control from (1) Phytoactin L-439 and L-440, both at 400 and 600 ppm concentrate, and (2) Mertax (2-mercaptobenzothiazole), 1.0 percent concentrate. Only Phytoactin L-440 appeared to offer any promise of control beyond the limits of actual treatment. Ten additional tests, on 160 ponderosa pine saplings, were initiated on the same area in 1962. Materials, applied in stove oil carrier, included cycloheximide (400 and 600 ppm), m-cresyl acetate (2.5 percent), o-phenylphenol (1.25 percent) and three chlorinated phenols (0.5 to 2.0 percent).

UNIT VI. DWARFMISTLETOES ON PINES

C. R. Quick, Compiler

The venerable forerunner of this summary was the report by Lake Gill in Proceedings 3rd W.I.F.D.W.C., Spokane, December, 1955, pp. 18-25.

Keith R. Shea reports that data on their chemical control work with dwarfmistletoes are tied up in patent proceedings and cannot be reported at this time.

P. C. Lightle and later R. V. Bega, started in 1955 and 1956, a series of spray tests on dwarfmistletoe on Jeffrey pine north of Chilcoot, Plumas National Forest, California. Various concentrations of eight materials, largely phenoxy herbicides, were applied in water at different seasons of the year. Included were MCPA-BOEE, MCPA-638, 4-CPA-BOEE, 4-CPA-638, 4-CPA-Amine, Chloro-IPC, and a disodium methyl arsonate material. No treatment was satisfactory, perhaps because of the water carrier.

F. G. Hawksworth reports that little or no control of Arceuthobium americanum on lodgepole pine (Roosevelt National Forest, Colorado) resulted from spraying the parasitic plants in 1958 and 1959 with a number of pesticides in water carrier. Included in the list of materials were (1) maleic hydrazide at 0.025 to 2.0 percent; (2) various formulations of cycloheximide (Actidione) and cycloheximide derivatives, all at 30, 100, and 300 ppm; (3) Tin-San (tributyl tin complex) at 1 ppm to 1 percent; and (4) Solan (Niagara #4512), Dicryl (Niagara #4556), Karsil

(Niagara #4562), and Niagara #5996, all at 1/2, 2, and 8 pounds active per 100 gallons. Additional tests were initiated in 1960 on A. americanum on lodgepole pine and on A. vaginatum on ponderosa pine, on the Roosevelt National Forest. Most tests were treatments of infection only, and all were applied in water carrier. No promising leads were found.

C. R. Quick reports an assortment of tests on dwarfmistletoes on pines during the period 1959-1962. Most materials were applied in solution or suspension in liquid carriers with a pump-up garden sprayer. Treatments were largely basal-stem spray, or infection-only spray, with a heavy trend towards infection-only treatments as the study progressed. Most tests were made with one of the following spray carriers: (1) petroleum fuel oil only, (2) fuel oil with added solvents, (3) water with 10 percent to 30 percent agricultural (emulsifiable) spray oil added, and (4) water with 10 percent to 30 percent of a glycol added. Most tests, and in general the more successful tests, were made with phenoxy herbicides and closely related materials.

In Quick's experience, pine species differ considerably in their tolerance to phenoxy herbicides in oil carriers. Ponderosa pine is easily damaged and killed; Jeffrey pine perhaps is less so; and sugar pine appears somewhat more resistant. Fuel oil alone, or with added solvents, is a very effective carrier of oil-soluble and oil-miscible herbicides, but attempts at systemic control often damages trees. A few basal-stem treatments have given fair systemic control of dwarfmistletoe, but the safety zone between killing the parasite and killing the tree is often small. Tests on dwarfmistletoe cannot be evaluated quickly--some infections treated in 1959 now look as if they were going to resprout in 1963! Resprouting of sprayed cankers almost always is distal--above a bole canker and beyond a limb canker. Except on large limbs, killing a limb canker with herbicide in oil almost invariably kills the limb distal to the canker.

Data from the 1962 check of Quick's 1959 treatments indicate that the following materials were reasonably effective in killing dwarfmistletoe plants on Jeffrey pine, by direct spraying, with little or no damage to the trees. All herbicides were applied in Pearl Oil, a highly refined kerosene.

Weedone LV-4	(24-DA-BOEE).	0.20 percent.
ACP-L-702	(MCPP-BOEE).	0.20 percent.
ACP-L-685	(24-DP-BOEE).	0.20 percent.
ACP-L-661.	(MCPA-638).	0.40 percent.

Several materials and concentrations in the same series of tests were too "hot"; they killed too many trees, especially when applied as basal stem treatments.

The following materials, applied by Quick in 1960 to dwarfmistletoe on sugar pine as infection-only treatments, show good promise of control without undue host damage. All were applied in 15 percent to 30 percent glycol (commonly Carbowax 1500) in water.

ACP-L-372.	(MCPA-BOEE).	1.0 percent.
MCP Amine WK.	(MCPA-Amine).	2.0 percent.
Methoxone	(MCPA -Sodium).	2.0 percent.
Weedar 64	(24-DA-Amine).	1.0 percent.
Weedone LV-4	(24-DA-BOEE).	1.0 percent.
ACP-L-578	(24-DP-BOEE).	1.0 percent.
ACP-L-753	(24-DB-BOEE).	1.0 percent.

Thus it seems that the carrier-concentration combination is fully as important as choice of material in infection-only treatments.

Results from Quick's 1961 tests are still little more than suggestions, but a few comments may be ventured. Best chance for development of an effective systemic treatment of dwarfmistletoe on sugar pine seems to be with 245-TP. Two formulations have given highly promising preliminary results: Kuron (Dow, 245-TP-PGBEE), 2.5 percent a.e. in 20 percent oil-water emulsion, and Weedone 245-TP (245-TP-BOEE), 2.5 percent a.e. in the same carrier.

On Blacks Mountain Experimental Forest, Lassen National Forest, 1961 tests on Jeffrey pine-ponderosa pine mixture with 245-TB-IOE at 0.20, 0.324, 0.54, 0.90, and 1.50 percent in stove oil currently promise excellent direct effectiveness with no damage to hosts. Tests with (Pittsburgh) LoVol 4 Brush Killer (24-TA-IOE), circa 1953, at 0.20 percent in stove oil and in oil-water emulsion are equally promising.

UNIT VII. DWARFMISTLETOE OF DOUGLAS-FIR

Keith R. Shea, Compiler

Data of the Forestry Research Center, Weyerhaeuser Company, on experimental chemical control of dwarfmistletoes are tied up in patent proceedings and cannot be presented at this time. No one else was found who had data to offer in this unit.

UNIT VIII. DWARFMISTLETOES ON TRUE FIRS (ABIES SPP.)

C. R. Quick, Reporter

C. R. Quick applied various materials and concentrations in stove oil as basal-stem or bole-band treatments in early July 1960 to dwarfmistletoe on red fir (Abies magnifica) at about 6,800 feet altitude (Stanislaus National Forest). The following caused death or heavy damage to the host:

Weedone LV-4	(24-DA-BOEE).	0.6 and 0.8 percent.
ACP-M-578.	(24-DP-BOEE).	0.8 percent.
ACP-M-753	(24-DB-BOEE).	0.4, 0.6, and 0.8 percent.
LoVol 4 Brush Killer	(245-TA-IOE).	0.8 percent.
ACP-L-372.	(MCPA-BOEE).	0.8 and 1.0 percent.

The following materials and concentrations as basal-stem and bole-band treatments in stove oil, when applied in mid-July 1960 to dwarfmistletoe on white fir saplings (Abies concolor) near Cow Creek Guard Station, Stanislaus National Forest, killed all trees to which applied:

Weedone LV-4	(24-DA-BOEE).	0.4, 0.6, and 0.8 percent.
ACP-M-578.	(24-DP-BOEE).	0.6 and 0.8 percent.
ACP-M-753	(24-DB-BOEE).	0.4, 0.6, and 0.8 percent.
Esteron Ten-Ten.	(24-DA-PGBEE).	0.6 percent.
Stantox P-44	(24-DA-IPE).	0.6 percent.

The following materials in water carrier to which 1 part in 10 to 1 part in 4 of a glycol (largely Carbowax 1500) had been added, were applied in September 1960 to dwarfmistletoe on white fir saplings near Cow Creek Guard Station. All were generally ineffective but caused no serious damage to the tree hosts:

Hydrazine salt of 24-DA at 0.25 and 0.50 percent.
Atrazine 80-W at 0.5 percent active.
Simazine 80-W at 1.0 percent active.

Additional tests were applied in August 1961 in stove oil carrier to white fir regeneration near Cow Creek Guard Station. Tests were mixed treatments of infestation only and basal-stem sprays. Chipman 245-TB-IOE at 0.2, 0.3, and 0.5 percent gave good apparent control (1962) of treated infestation, but little or no systemic control, and caused no appreciable damage to host trees. Weedar OSA 245-T (245-TA-OSA) at the same concentrations gave excellent apparent control of sprayed infestation (1962) but injured some host trees. Esteron 245-T (245-TA-PGBEE) at the same concentrations killed many fir saplings.

UNIT IX. LEAFY MISTLETOES (PHORADENDRON SPP.)

C. R. Quick, Compiler

H. I. Graser (Agriculturist Emeritus, Agricultural Extension, Yuba City, California) back in 1947-1955 made many tests with herbicides for control of Phoradendron on black and English walnuts in the Sacramento Valley. Treatment was always on dormant trees. A compressed air sprayer was used; only the mistletoe was sprayed. No host damage resulted. Results of some tests initiated in 1950 and checked in 1954 follow. (DEO designates Dormant Emulsive Oil, an agricultural spray oil.)

(1) 88 percent (7 clumps killed out of 8 sprayed). Stantox 33 (24-DA-Amine), 2 tbs. (1 fl. oz.). DEO, 1.25 tbs. (0.625 fl. oz.). Water, 1 quart (32 fl. oz.). Final dilution of formulation, 1 part in 33.625 total parts, or about 3 percent v/v.

(2) 83 percent (5 clumps out of 6). A formulation of 245-TA, 1 tbs. (0.5 fl. oz.). DEO, 2 tbs. (1 fl. oz.). Water, 1 quart. Final dilution, 1 part in 33.5, or about 3 percent v/v.

(3) 82 percent (9 out of 11). Esteron 44 (24-DA-IPE), 2 tsp. (1/3 fl. oz.). DEO, 2 tbs. (1 fl. oz.). Water, 1 quart. Final dilution, 1 part in 100, or 1 percent v/v.

(4) 78 percent (7 out of 9). Esteron 44 (24-DA-IPE), 2 tsp. (1/3 fl. oz.). Methanol (wood alcohol), 1/2 pint (8 fl. oz.). Water, 3/4 quart (24 fl. oz.). Final dilution, 1 part in 32.33, or about 3 percent v/v.

P. D. LaVine (Agricultural Extension, Modesto, California) treated Phoradendron clumps on completely winter-dormant Modesto ash trees with aminotriazole. Some clumps were carefully painted; others were sprayed. Both methods of application caused considerable injury which became apparent on the ash trees the following spring.

D. H. Chaney (Agricultural Extension, Yuba City, California) is continuing work on control of mistletoe on black and Persian walnuts. Materials were applied by backpack rig in February and March. Test batch volume was 1 quart, of which 2 fl. oz. (59.16 ml./quart; 62.5 ml./liter) commonly were agricultural spray oil. No appreciable host toxicity resulted from the tests. The most promising 1960 tests—1962 data—are described as follows:

(1) 100 percent (5 clumps). Weedar 64(?) (24-DA-Amine), 1 percent. Light summer oil, 2 fl. oz./qt.

(2) 100 percent (3 clumps). Weedar 64(?) (24-DA-Amine), 1.5 percent. Dormant emulsive oil, 1 fl. oz./qt. (The 24-DA-Amine formulation applied without addition of spray oil gave little or no kill of the parasite.)

(3) 80 percent (8 out of 10 clumps). Dow Kuron (silvex, i.e., 245-TP-PGBEE), 1 percent. Dormant emulsive oil, 2 fl. oz./qt.

(4) 78 percent (7 out of 9 clumps). Weedone LV-4 (24-DA-BOEE), 1 percent. Dormant emulsive oil, 2 fl. oz./qt.

Aminotriazole, maleic hydrazide, and ammonium sulfate, as used, were unsatisfactory.

J. L. Orr (Forester, Yosemite National Park) in the spring of 1962 initiated several tests for the control of Phoradendron on California black oak (Quercus kelloggii). Materials were mixed with water, and applied only to parasitized shrubs with a back-pack sprayer. Aminotriazole and 2-4 Dow Formula 40 (24-DA-Amine) were tested. The mistletoe shortly lost color and vigor, but results are not yet readable.

C. R. Quick in late August 1962 started two small tests on Phoradendron libocedri on incense-cedar near Cow Creek Guard Station, Stanislaus National Forest. One test was made with 0.5 percent a.e. 245-TB-IOE in 10 percent oil-water emulsion; the other with 0.5 percent a.e. 24-DA-BOEE in stove oil.

UNIT X. CONTROL OF ELYTRODERMA DEFORMANS (WEIR) DARKER

G. M. Harvey, Compiler

G. M. Harvey in 1960 started two parallel series of tests with antibiotics on Elytroderma deformans and on Pinus ponderosa near Deer Creek, Malheur National Forest, Oregon. The following materials were applied in both sets of tests: cycloheximide (Acti-Spray), cycloheximide methylhydrazone, cycloheximide acetoacetate, and phytoactin. The cycloheximide materials were applied at 50 and 100 ppm, the phytoactin at 200 and 400 ppm. Hand operated spray equipment was used in all tests. Materials in fuel oil were applied as basal-stem sprays in one set of tests and in water only as overall crown spray in the other series.

No treatment showed promise of controlling the disease. Heavy damage to ponderosa pine was caused by cycloheximide (Acti-Spray) in both basal-stem and crown sprays, and by cycloheximide aceto-acetate in the basal-stem treatments. Moderate damage to host trees was caused by cycloheximide methylhydrazone in basal-stem treatments and by cycloheximide acetoacetate in crown sprays. Light damage was caused by the phytoactin basal-stem treatment. No damage was caused by cycloheximide methylhydrazone and phytoactin in dilute-aqueous crown sprays.

C. R. Quick in 1959 treated Jeffrey pine saplings severely infected with Elytroderma deformans near Cow Creek Guard Station, Stanislaus National Forest, California, with Glyodin Solution Crag (glyodin), 0.2 percent; Cyprex 65-W (dodine), 0.4 percent; and Dowicide 1 (o-phenylphenol), 0.4 percent. All materials were applied in kerosene as basal-stem sprays or as direct treatments with a pump-up garden sprayer. All test batches were "fortified" with 2,000 ppm of 24-DA (Weedone LV-4). There seemed to be a slight curative effect from these sprays, but some trees in all tests were severely damaged or killed. A single test on sapling ponderosa pine near Pacific Southwest Branch Station, Stanislaus National Forest, was made in 1960 with cycloheximide (Acti-dione BR Aerosol, 300 ppm) as basal-stem spray. Curative effects, if any, were minor, but here too some trees were severely damaged or killed.

UNIT XI. CONTROL OF RHABDOCLINE PSEUDOTSUGAE SYD.

L. C. Weir, Reporter

L. C. Weir in 1960 initiated a large number of antibiotic control tests on Rhabdocline needlecast on Douglas-fir at Canal Flat, British Columbia. Cycloheximide was tested as Acti-dione BR Concentrate and Acti-dione 1.28% Solution, and as formulations of the acetate, acetoacetate, methylhydrazone, oxime, semicarbazone, and thiosemicarbazone derivatives. These eight materials were applied at 100, 200, 400, and 800 ppm as (1) basal-stem sprays in stove oil and as (2) overall foliage sprays in oil-water emulsion. Phyto-Pabst L-317 at 100 ppm, L-318 at 200 ppm, and L-319 at 400 were similarly applied. Hand equipment was used. Checks of no treatment, stove oil carrier only, and oil-water carrier only were established.

An additional series of tests was initiated in 1961, but results from this later set of tests are not here being reported.

Phytoactin treatments of 1960, both basal spray and foliar application, caused no tree mortality. Heavy tree mortality occurred with most of the cycloheximide derivatives when applied as basal stem sprays, but not when applied as foliar applications. No trees were killed, no defoliation, and little or no control resulted from check spray treatments.

In the cycloheximide basal sprays of 1960, treatment with thiosemicarbazone appeared outstanding--no trees were killed, no excess defoliation was caused, and relatively few infected needles were found at inspection. Perhaps the next best cycloheximide formulation in the basal spray series was Acti-dione BR Concentrate. Basal stem treatments with the phytoactins resulted in good control of infection with no defoliation.

No trees were killed and little defoliation was caused by phytoactin in foliar applications, but infection control as measured by per cent infected needles at inspection was slightly less than with the best cycloheximides. In the cycloheximide series of foliar applications, Acti-dione BR Conc. and Acti-dione 1.28% Solution at 100, 200, and 400 ppm caused considerable defoliation but no tree mortality, and gave control of infection. Best all round material in this series probably was the semicarbazone derivative followed by the oxime derivative. Cycloheximide methylhydrazone caused no tree mortality and no defoliation but gave less control.

In all series of cycloheximide tests, both basal spray and foliar application, effects due to concentration of fungicides were peculiarly hard to find in the 100-400 ppm range. The average difference between the 400 and the 800 ppm tests often was readily apparent.

E. F. Wicker and C. D. Leaphart (Plant Disease Reporter 45(9): 722-724, 1961) report on aerial treatments with Acti-dione BR Conc. at 100 ppm, cycloheximide semicarbazone at 100, 200, and 400 ppm in 20 per cent oil-water emulsion, and phytoactin at 100, 200, and 400 ppm in water only. All were applied by helicopter at the rate of 10 gallons/acre during the first week in June 1959. Wicker and Leaphart, on the basis of first year's observations comment," . . . evidence of control appeared on Douglas-fir trees infected with Rhabdocline pseudotsugae in plots treated with cycloheximide semicarbazone. The extent and degree of control are recorded for this disease by areas and treatments . . . Where control was observed, it ranged from partial (intensities less than the previous season's infection) to complete (no new infection and/or arrestment of the normal disease process)."

UNIT XII. CANKERS OF ASPEN AND OTHER POPULUS SPP.

T. E. Hinds, Compiler

"In summation, it appears that phytoactin, cycloheximide and its derivatives are ineffective in suppression of *Cenangium singulare*, *Cytospora chrysosperma*, and *Hypoxylon pruinatum* cankers on *Populus tremuloides* at a concentration of 200 ppm in a No. 2 petroleum oil spray carrier when used as a basal spray. The effects of Actidione BR Aerosol on a Nectria-like canker of aspen in Colorado look promising but the test is too recent to be evaluated."

UNIT XIII. ROOT ROTS EXCLUSIVE OF NURSERY TROUBLES

F. G. Hawksworth, Compiler

F. G. Hawksworth reports virtual loss of a series of tests on root rot in lodgepole pine due to an overly ambitious thinning crew.

R. V. Bega reported on an outbreak of *Fomes annosus* in the arboretum of the Institute of Forest Genetics at Placerville, California, in Plant Disease Reporter 46(2): 107-110, 1962. Control of the fungus in the arboretum by soil fumigation is being attempted. Comments by Bega on this work follow.

Attempts at direct control are justified because of the extremely high value of this pine breeding arboretum. Two methods of control are being attempted. Eradicant control methods, involving stump and large root removal followed by soil fumigation with 450 pounds/acre of methyl bromide, are aimed at eradication of the fungus from the infection centers. Barrier trenching, i.e. digging a 2-foot wide by 3-foot deep trench around each infection center, removing all roots from the trench and refilling it, then periodically fumigating the trench with carbon disulfide to prevent growth of roots across the trench, is aimed at halting spread of the disease by roots. Results will not be final for several years. However, preliminary tests with both fumigants have shown them capable of killing the fungus in 3-inch diameter roots buried 2 feet in the soil.

UNIT XIV. BROOM RUSTS AND YELLOW WITCHES' BROOMS

R. S. Peterson, Compiler

No data from tests attempting control of yellow witches' broom of firs were received.

R. S. Peterson reports that in 1960 Engelmann spruce trees infected with spruce broom rust (Arapaho National Forest, Colorado) were sprayed basal stem with Acti-dione BR Aerosol (eight trees) and with phytoactin (ten trees), 200 ppm in No. 1 fuel oil. All or nearly all brooms above the spray zone on treated trees were producing new pycnia in 1962. The one broom sprayed directly (with Acti-dione BR Aerosol) was apparently dead in 1961 and 1962. No brooms were sprayed directly with the fuel oil carrier only. No systemic host toxicity was observed.

UNIT XV. MISCELLANEOUS FOREST DISEASES

C. R. Quick, Compiler

E. F. Wicker and C. D. Leaphart (Plant Disease Reporter 45(9): 722-724, 1961) report on a series of 10-acre test blocks near Bovill and Clarkia, Idaho, sprayed by helicopter (10 gallons/acre) in early June 1959 with (1) phytoactin (100, 200, and 400 ppm) in water only, (2) cycloheximide at 100 ppm in 20 per cent oil-water emulsion, and (3) cycloheximide semicarbazone (100, 200, and 400 ppm) in 20 per cent oil-water emulsion. They comment, "No evidence of control of Peridermium harknessii, Hypodermella arcuata, or Lecanosticta sp. was detected in any spray block . . . Other diseases, Coleosporium asterum on lodgepole pine, Didymascella thujina on western red cedar, Hypodermella concolor on lodgepole pine, and Phomopsis boycei on grand fir occurred only sporadically in both control and treated blocks . . . However, empirical observations showed no evidence of control of these diseases."