# PROCEEDINGS OF THE 17th ANNUAL WESTERN INTERNATIONAL FOREST DISEASE WORK CONFERENCE

**Olympia, Washington**
**September 1969**

# Proceedings of the 17th Annual Western International Forest Disease Work Conference

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# FOREWORD

The Seventeenth Western International Forest Disease Work Conference was held September 23-26, 1969, at the Tyee Motor Inn, Olympia, Washington, U.S.A. Seventy-eight members and guests registered.

The conference was called to order on Tuesday morning, September 23, by chairman, Gordon W. Wallis. The welcoming remarks were ably delivered by Dan Lee Frazier, Supervisor, State of Washington Department of Natural Resources. Representatives of the various research labs, schools, etc. gave brief project reports for the remainder of the morning. Panel I, "Succession of Organisms in Discoloration and Decay in Living Trees" was held Tuesday afternoon. We were particularly fortunate in having Alex Shigo, pioneer researcher in this field, to chair this panel.

On Wednesday, September 24, the conference began with three concurrent workshop panel discussions. Leaders of these panels presented summaries after the conference reassembled.

Panel II, "Economics of Forest Disease Control" occupied the program on Wednesday afternoon, ably chaired by Keith Shea. The Banquet occupied the Wednesday night spot on the program, preceded by a typically sedate children's hour.

The field trip was held on Thursday, September 25, and the business meeting on Thursday night.

Friday morning started off with Panel III, "Forest Pathology in a Crowded World," with Don Knutson as moderator. After lunch an invited paper by Jim Trappe and special papers by Wayne Wilcox and Leonard Felix were presented. The conference adjourned at 3 p.m.

Executive Committees

Gordon W. Wallis, Chairman

R. L. Gilbertson, Secretary-Treasurer

Program Committee

Frank G. Hawksworth, Chairman

Local Arrangements

Ken Russell, Chairman

Charles Driver

Conference Historian

G. W. Wallis

## OPENING REMARKS

Chairman Gordon W. Wallis

Mr. Bert Cole, guests, and members, it gives me a great deal of pleasure to welcome you and to call to order this meeting of the Western International Forest Disease Work Conference, the seventeenth since its inception in November 1953.

Since our last meeting, two of our colleagues, Dr. Jess Bedwell and Dr. Lake Gill, both Honorary Life Members and Charter Members of these Work Conferences, passed away. Jess, as many of you know, spent many years with blister rust control before taking charge of the Portland Office in 1935, a position he filled wisely and conscientiously until his retirement in 1958. Jess will be remembered with respect and affection by his many friends and colleagues. Lake died July 5, in Phoenix. He will be remembered for his monograph on Arceuthobium which appeared in 1935 and for his long, most productive and, in many respects, missionary career in the mistletoe field.

I would ask you to join me now in silence in memory of two friends, Jess and Lake.

To those of you who are attending the Conference for the first time, on behalf of us Oldies, welcome. The Conference owes much of its success to informality and uninhibited mass participation. So, although we hope that you will take away with you something worthwhile, we sincerely wish to have the benefit of your deliberations, so do not hesitate to join in the fray; I should warn you that things usually get "frayer" and "frayer" as the night wears into morning.

Unfortunately, our friends from Mexico were unable to arrange authorization to attend the Conference so again they cannot be with us. However, Rodolfo Salinas Quinard has sent an invitation to the Conference to consider Mexico as its location for the 19th or 20th session; this can be considered at the appropriate time in the business meeting.

Your Chairman has it seems, if I have read past Proceedings correctly, acted in a very Chairmanship-like manner in that others have done all the work. My sincere thanks to: Frank Hawksworth for accepting the job of Program Chairman and for proceeding in a most unruffled manner to round up volunteers to present what you will find, I am sure, a very interesting and stimulating program; Ken Russell, who, as Chairman of Local Arrangements, had this meeting place in hand before we left last year's Conference and who, throughout the year, finalized details for this meeting and the banquet, and arranged a field trip which will give everyone attending a closer insight into the problems facing us here in the Northwest. I would also like to thank Ken's wife for her part in the excellent arrangements set out for the ladies.

Finally my thanks to Bob Gilbertson, our Secretary-Treasurer for the large amount of work he has already had to do as Secretary and, in advance, for the tedious job he has ahead of him in getting out the Proceedings. My thanks also to Bob's secretary, Miss Adela Saucedo, for translating the letters we received from the Mexican members and for replying to same.

Our Program Chairman has provided us with stimulating speakers in a range of topics of interest to all. Ample time has been allowed for following the speakers so I urge everyone to take full advantage of it to agree or disagree with thoughts expressed; the real success of these meetings still lies in uninhibited mass participation.

It is now my privilege to introduce to you the first speaker of this 17th conference. He is Supervisor, State of Washington, Department of Natural Resources, and as such is well known to many here in the Northwest; Mr. Don Lee Fraser.

## WELCOMING REMARKS

Don Lee Fraser

(Editor's note) No copy of the welcoming remarks was submitted for inclusion in these proceedings. Mr. Fraser emphasized the fact that we are becoming pressed in from all sides from cities and urban populations, by preservationists and conservationists, forcing us to practice more intensive forestry on less land. This puts considerable pressure on us, as disease specialists and researchers to develop control measures for as many diseases as possible in order to allow us to increase the sustainable harvest.

## PANEL I. SUCCESSION OF ORGANISMS IN DISCOLORATION AND DECAY IN LIVING TREES

Alex L. Shigo, Moderator

### INTRODUCTION

Alex L. Shigo

The need for an expanded concept of decay in living trees was stressed. The original concept of decay, as outlined by Robert Hartig a century ago, centered about three main points: A wound, a fungus (meaning a Hymenomycete), and decay. Now we need a larger framework. We need to add response of the tissues to wounding, bacteria, nonhymenomycetous fungi, interactions of these organisms among themselves and with the host, and environment to the concept of decay.

We need to understand the sequences of events and the successions of organisms that follow wounding. And, when the organisms invade the tree, we need to know the patterns they follow. Details on these points are given in publications by the author.

### THE COMPETITIVE AND REGULATORY ROLE OF NON-HEARTROT FUNGI IN THE DECAY PROCESS OF CONIFERS

D. E. Etheridge

The classical understanding of the decay process in forest trees is built on the concept of a single causal agent, usually a Hymenomycete; the associated fungi and bacteria being regarded merely as contaminating organisms. In recent years, however, increasing attention has been paid by decay investigators to the role of the associated microflora, and there is a growing realization that we are dealing with a very complex and dynamic ecological situation in decaying trees, something more than the classical Hartigian host-pathogen-decay concept implies.

The considerable research emphasis placed on successions and interactions of microorganisms associated with decay and discoloration in hardwoods has led to interesting hypotheses by Shigo (1967) and Good et al. (1967) that the initial stage in wound colonization involves bacteria, moulds, and imperfect fungi which serve to modify the substrate for the decay-producing Hymenomycetes. However, the work of Rishbeth (1950, 1951a), Boyce Jr. (1963), and others with Fomes annosus, and my own work on wound infection by Stereum sanguinolentum, suggest a different situation may exist in conifers, where the initial stage in the colonization of wounds involves invasion by Hymenomycetes.

This paper discusses examples of how wood-inhabiting microorganisms, other than those traditionally held responsible for the final decay, affect infection and development processes of decay in conifers.

In conifers, unlike the hardwoods studied, such organisms are not always required by decay pathogens for the purpose of modifying an unfavorable substrate. With some pathogens, notably F. annosus and S. sanguinolentum, they may be intimately involved in the process, but only in a competitive and regulatory role.

The earliest and possibly best known examples of microbiological competition affecting the decay process in conifers come from the studies of Rishbeth (1950, 1951a) on the ecology of stump infection by F. annosus. Rishbeth was the first to recognize that F. annosus requires a fresh, uncolonized wound surface for successful invasion of the host, and concluded that it rarely, if ever, infected trees through dead roots occupied by other fungi. In this respect, F. annosus resembled Armillaria mellea which Leach (1939) earlier had claimed was unable to attack roots invaded by saprophytes. Both these observations resulted in classic examples of biological control against root pathogens, through intensifying saprophytic competition at the infection site. Rishbeth (1952, 1961), by inoculating freshly cut stumps with a natural competitor, Peniophora gigantea, was able to substantially reduce subsequent invasion and spread of F. annosus, while Leach (1939), by ringing shade trees in tea plantations before felling, favored competition in roots by soil saprophytes which prevented invasion and spread of A. mellea to adjacent tea plants. Subsequent studies, elsewhere, showed that neither of these control methods had general application. Recently, however, Driver and Ginns (1969) have observed that seasonal and geographical variations in stump infection by F. annosus are largely due to the effect of climatic factors on the relative occurrence and competitive ability of the associated wound flora, especially P. gigantea and Trichoderma spp., and have stressed the importance of studying this disease on the basis of the ecosystem involved.

S. sanguinolentum, one of the most destructive heart-rotting fungi attacking conifers, is similar to F. annosus, in that it requires a fresh wound uncolonized by other organisms for successful invasion of the host (Davidson and Etheridge, 1963). As a result of recent studies in Quebec (Etheridge, 1969), we have been able to show that, like F. annosus, the susceptibility of the host to S. sanguinolentum is determined by temperature and moisture factors of the ecosystem acting on the competitive ability of a specific wound surface microflora. Depending on conditions prevailing at the time of the injury, the succession of organisms colonizing wounds of balsam fir can involve either a heartrot-producing one spearheaded by S. sanguinolentum, or one consisting of organisms which rarely penetrate more than three inches into the heartwood, from the wound surface, e.g., Ceratocystis picea and Alternaria tenuis. Thus, wound surfaces exposed during periods characterized by mean temperatures greater than 60°F, are colonized initially by a microflora dominated by either C. picea and A. tenuis, when conditions are dry, or by Peniophora cinerea followed by C. picea, etc., when conditions are humid. Prior colonization of the wound by either of these successions usually prevented infection by S. sanguinolentum, which could compete successfully only when mean temperatures were between 45 and 55°F, and the

substrate was freshly exposed. A fresh substrate, especially heartwood, was important because of properties that acted selectively for S. sanguinolentum by increasing its growth rate in relation to that of its competitors during the initial colonization period (Etheridge, 1962; Hubbes and Etheridge, 1965, Etheridge, 1969).

The foregoing are a few examples of how nonheartrot organisms can, under certain conditions, adversely influence the development of decay through successful competition for available infection sites. There are also examples of organisms associated with advanced decay in conifers that initially were not involved in the succession. The role of these fungi may be regarded as regulatory. The early work of Rishbeth with F. annosus (1951b) provides one of the best examples of this situation in the description of the course of several successions involving F. annosus in a rotted spruce butt. According to Rishbeth, F. annosus was abundant in rotted regions continuous with those of the butt. Thus, butt rot was almost certainly initiated by F. annosus, but in two of the columns successions spearheaded by Hypholoma fasiculare eventually became dominant. It is interesting to note that F. annosus was not replaced by these other fungi in the rotted roots. It is also interesting to speculate that, in general, replacement of root and butt-decay pathogens by other fungi more suited to an aboveground environment may be a major reason for the restricted upward extension of rot columns originating in roots.

The possibility that replacement and eventual containment of decay pathogens by nonheartrot organisms, such as suggested here, may occur in living trees is highly intriguing. There is evidence of at least two such fungi in living conifers which, under certain conditions, may have this function. The most common is Ascocoryne sarcoides, perhaps better known as the Coryne sarcoides complex, which I have studied in considerable detail over the past 15 years. There is reliable evidence that A. sarcoides colonizes injured roots of young conifers as a saprophyte before butt and stem rot is initiated. It then proceeds to colonize the dead tissues of the pith, slowly extending up the stem to a maximum height of about 35 feet. During this time, it rarely penetrates the outer heartwood unless contact is made with a heartrot infection, in which case it proceeds to colonize the peripheral zone around the column of rot.

The other fungus is Kirschsteiniella thujina, which causes a heart-blue stain of eastern balsam fir and cedar. This fungus is primarily an initial colonizer of suppressed and dying branches but, like Ascocoryne, is initially restricted in its development (in this case to branch stubs) until contact is made with outward extensions of heartrot when it proceeds to colonize the peripheral zone of these infections.

Studies, in vitro, have shown that some isolates of A. sarcoides and K. thujina are strongly inhibitory to the development of decay (Etheridge, 1957; Pomerleau and Etheridge, 1961). These results support the suggestion that in living trees such fungi may, under certain conditions, eventually replace or prevent further development of the primary heartrot fungus. It is certainly true that K. thujina, which together with Retinocyclus abietis, completely dominates dead branch stubs of balsam fir, provides an effective "microbiological barrier" to the entry of S. sanguinolentum.

It is significant that this so-called microbiological barrier involving K. thujina appears to be a common feature of such trees of the coniferous genera Abies, Tsuga, and Thuja which do not possess a resinous sapwood and consequently have no other means of sealing off wounds. On the other hand, the so-called "resin barrier," which is the common wound protectant in the genera Pinus and Picea, may represent a good example in conifers where nonheartrot microfungi are required by a decay fungus to modify the wound substrate. It appears from the work of Bourchier (1961) that some of the heartrot fungi occurring on pines and spruce, namely, F. pini and P. pseudopini, may require specific successions of microfungal precursors such as R. abietis, Zythia resinae, and Tympanus hypopodia to remove the resin from wound tissues before penetration by a decay fungus is possible. While such successions involving decay pathogens has not been clearly demonstrated, there is some evidence that F. pini, at least, is not a primary invader of wounds but appears in the succession only after 4 or 5 years have elapsed.

To summarize, there is growing recognition of the importance of associated microorganisms in the decay process of forest trees. This process may involve successions where the nonheartrot organisms are primary, as in the northern hardwoods studied by Shigo and in some conifer decays; or secondary, as we have seen for the fresh-wound pathogens F. annosus and S. sanguinolentum. When the associated microorganisms are primary, their role may be beneficial from the standpoint of the pathogen - creating a more suitable, perhaps more acid or less resinous substrate for the heartrot-producing hymenomycete. When they are secondary, their role may be competitive or regulatory, as in successions involving F. annosus and S. sanguinolentum. Colonization of the fresh-wound surface by nonheartrot organisms produces a microbiological barrier in Abies, Tsuga, and Thuja which appears to serve a purpose comparable to the resin barrier in Pinus and Picea. In the latter two genera, we find heartrot successions involving F. pini and P. pseudopini which may require prior colonization by other organisms whose principal function seems to be destruction of the resin barrier and detoxification of heartwood compounds.

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## MICROORGANISMS ASSOCIATED WITH DECAY IN YOUNG GRAND FIR

Otis C. Maloy

Decay of grand fir has been of particular concern to me since 1949, when I was employed as research forester by Potlatch Forests, Inc of Lewiston, Idaho. PFI owns about a half million acres of timberland in northern Idaho. Past management practices had resulted in large volumes of grand fir, in all age classes, on these lands.

Of primary concern to the managers of this timber was the serious decay attributed to the Indian Paint fungus, Echinodontium tinctorium. One study had been initiated in 1955 to determine the effectiveness of sanitation procedures to reduce the inoculum potential in areas of grand fir reproduction (1). Because these studies indicated that sanitation procedures would probably be of little value in reducing the inoculum potential or subsequent infection of trees, a more feasible approach to control seemed to be to formulate a pathological rotation for grand fir. For this we needed to determine the earliest age of infection and the rate of decay. Two studies were established to obtain this information

The first involved the critical dissection of trees in a range of age classes to determine earliest age of infection and possibly other facts (4). Basically we found that decay can occur very early in the life of a tree and that most of the decay appeared to have originated at wounds. The second observation was in sharp conflict with the traditionally designated infection court for E. tinctorium, namely, dead branch stubs. This point has been discussed in detail in a review of this fungus (2).

In this dissection study we did not attempt to determine what fungi were present, but, on the basis of the literature, we assumed that most of what we detected was caused by E. tinctorium.

A companion study was started in 1961 to measure the rate of decay in grand fir. Young grand fir trees were inoculated with a mixture of decayed wood from a column of advanced decay and context from an apparently viable E. tinctorium sporophore. This mixture was packed into an increment bore-hole and the hole plugged with a dowel. A sample of these trees has been dissected every two years to determine the rate at which the decay progresses.

In 1964 PFI foresters examined areas of grand fir reproduction in which logging operations several years earlier had caused severe damage to many of the young trees. Advanced decay was associated with many of the stem scars. It was decided to try to determine if E. tinctorium was the only decay fungus involved.

Initially 30 trees with an average age of 20-25 years were selected and 465 pieces of wood plated onto malt agar. Context material from an E. tinctorium sporophore was also plated to be certain that the fungus would grow under our study conditions.

The results were most disappointing because we did not recover a single isolate that resembled E. tinctorium. However, we noticed the consistent development of bacteria and types of imperfect fungi from certain categories of trees. We also recovered one basidiomycete, later identified as Stereum sanguinolentum, from two of the trees. Among the imperfects most frequently isolated were Phialophora- and Cephalosporium-like fungi.

We were most perplexed to explain our failure to recover E. tinctorium and decided to isolate from the trees inoculated with E. tinctorium as described above. Samples of discolored and presumably incipiently decayed wood were plated on malt agar but much to our confusion we did not recover E. tinctorium but consistently isolated Phialophora- and Cephalosporium-like hyphomycetes, as well as bacteria.

There was still the possibility that these imperfects were simply ubiquitous superficial fungi. To determine if they were actually invading the wood cells pieces of wood taken several centimeters from the inoculated area was macerated, stained with safranin, and examined microscopically. Many tracheids and ray cells contained hyphae of types not previously described as typical of E. tinctorium. Subsequent inoculations demonstrated that many of these imperfects were effective wood invaders.

The next stimulus to additional study was Shigo's paper (7) on organism interaction in decay. Cephalosporium and Phialophora were prominent among the imperfects isolated. This convinced us that we should extend our study.

We decided to expand our age classes and sampled an additional 32 trees from 40 to 170 years. Isolations yielded the same and some additional imperfects as the earlier isolations but no E. tinctorium. We did recover three additional wood decay fungi--Pholiota adiposa, Hericium abietis, and Odontia bicolor. To more thoroughly test our ability to isolate E. tinctorium, six trees bearing conks of this fungus were selected and isolations made from up to 17 different locations in the decay columns. E. tinctorium was recovered from an average of 34 per cent of the pieces plated and from up to 95 per cent of those from some portions of the bole. We are certain that if E. tinctorium is present we can isolate it.

Our results from this study have been published in two parts. One dealt with the various microorganism recovered (5); the second reported the recognized wood decay fungi that were obtained (3).

When we started these studies we accepted as fact that E. tinctorium was the primary, if not only, decay organism involved, but we finally concluded, we hope not prematurely, that a succession of micro-organisms is involved.

Bacteria appear to be the primary colonizers, for we isolated only bacteria from 46 per cent of the tissue pieces plated in the 15-30 class. This, in spite of the fact that malt agar, the medium used, is not particularly adapted to bacterial development. From older age classes bacteria were recovered as frequently, or more frequently than in the 15-30 year age class but almost always in combination with fungi. The role of bacteria is not certain but in view of several reports, and particularly some very early ones (6) bacteria may increase decay rates by certain decay fungi.

Some of the imperfect fungi isolated were difficult to identify but many of the isolates had characteristics of Phialophora and/or Cephalosporium. These are genera frequently reported by others working on organisms associated with decay and discoloration.

Coryne sarcoides, which frequently has been associated with decay by Canadian workers, was not definitely identified among our isolates. There were, however, isolates that imparted a purple stain to the agar, a reported characteristic of this fungus.

We have preliminary evidence that some of these imperfects actually inhibit or retard decay by E. tinctorium. Studies are now underway to determine if this inhibition is general or is specific toward E. tinctorium. If the latter, it would be convincing evidence of a functioning succession.

Even though other workers have reported a variety of decay fungi from certain of the western true firs, especially Abies lasiocarpa, we were very surprised at the number that we isolated. More perplexing of course was our failure to recover E. tinctorium.

Of the decay fungi obtained, S. sanguinolentum, appears to be a factor only in very young trees. Hericium abietis and Pholiota adiposa were isolated from a wider range of age classes and are probably the more important decay fungi in the series. In decay tests we have not been successful in getting decay with Hericium but Pholiota causes a very rapid and extensive decay, more of the type associated with A. grandis.

Neither Hericium nor Pholiota commonly fruit on living A. grandis but I have often seen recently killed trees with abundant Pholiota sporophores up and down the trunk. This has indicated that the fungus was present prior to the death of the tree.

We have concluded that the pronounced decay in A. grandis that has usually been attributed almost entirely to E. tinctorium is probably due to a succession of associated microorganisms.

Bacteria are the initial invaders through wounds, followed by imperfect fungi which themselves may invade in some type of succession.

Decays, like other plant diseases, have classically been attributed to "a single cause - a single effect" concept. The possibility that mixtures of organisms may be more important than pure cultures in some disease complexes has been suggested over the years but the pure culture technique has prevailed.

There are many areas where it should. But isn't it reasonable to believe that a physiologically inactive substrate, such as heartwood, would be invaded by a variety of succeeding organisms?

Parasitic invasion of living tissues definitely requires special, complex mechanisms that are probably not required in the invasion of "dead" material. This material is therefore more subject to colonization by a wider variety of organisms.

If any dead substrate were exposed to the total environment, it would be very surprising if a succession of organisms were not involved in the degradation of that substrate.

The decay in grand fir caused by or attributed to E. tinctorium has perplexed us for two reasons. First the fact that this is virtually the only fungus found fruiting on decayed grand fir trees. Yet we have rarely isolated the fungus from extensive or advanced decay in young trees which did not bear sporophores.

Secondly, E. tinctorium is usually associated with very extensive decay in grand fir. Often the entire tree is culled. Yet numerous studies have shown this fungus to decay wood very slowly under laboratory conditions. In fact, nonhost species such as pine have sometimes been decayed at a more rapid rate than host species.

A succession of organisms, sometimes inhibiting or sometimes stimulating other organisms in the succession, may help to resolve these apparently incompatible observations.

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## THE EFFECT OF RED-STAIN, WHITE-ROT, AND BROWN-ROT FUNGI OF PINUS CONTORTA VAR. LATIFOLIA ON ITS PHENOLIC HEARTWOOD EXTRACTIVES


A. A. Loman


Studies of wood-inhabiting fungi and their distribution in lodgepole pine (Pinus contorta Dougl. var. latifolia Engelm.) revealed that frequency of successful isolations as well as variety of species decreased from the pith to the newly formed heartwood and was minimal in the sapwood (Bourchier 1961, Robinson-Jeffrey et al. 1963).

One of the characteristics of the hard pine group to which lodgepole pine belongs, is the presence in heartwood tissues of considerable amounts of phenolic compounds which are readily extracted with acetone (Erdtman 1958). Healthy sapwood tissues of pines belonging to the hard pine group do not contain phenolic extractives, but measurable amounts are synthesized in slowly dying sapwood cells in sapwood-heartwood transformations, mechanical injury (Jorgensen 1961, von Rudloff et al. 1963) or fungal attack (Shain 1967).

Attempts to relate the relative resistance to fungal attack of hard pines to the presence of phenolic extractives in their heartwood tissues, resulted in their bioassay with wood-inhabiting fungi on 2% malt extract agar (2% MEA) (Erdtman et al. 1944, Rennerfelt 1943, 1945, Rennerfelt et al. 1955). The stilbenes pinosylvin (PS) and pinosylvinmonomethyl ether (PSME) had fungistatic (50 ppm) and fungitoxic (200 ppm) properties on 2% MEA, but the flavanones pinocembrin (PC) and pinobanksin (PB) were not inhibitory to fungi. In general, PSME was less toxic to fungi on 2% MEA than PS, and the laccase-producing white-rot fungi were more resistant to these phenolic compounds than the nonlaccase producing brown-rot fungi.

It now appeared that in lodgepole pine, the tissues richest in fungitoxic compounds supported the richest fungus flora. This apparent anomaly was investigated in the Calgary laboratory of the Canadian Forestry Service from 1966 to 1968. The working hypothesis of this study was that wood-inhabiting fungi have available to them, a wider spectrum of compounds which function as derepressors and regulators for enzyme synthesis, and as prosthetic groups, coenzymes and metallic ion cofactors for enzyme activity, in lodgepole pine heartwood tissues than in the standard bioassay medium, 2% MEA.

The mechanism of enzyme inhibition by PSME has been worked out (Lyr 1961, 1962). Lyr concluded that enzymes with -SH groups in their active sites were inactivated by PSME. These enzymes include the extracellular fungal cellulases, xylanases, pectinases, and certain proteinases. He further reported that laccase, which is produced by white-rot fungi, is not a -SH active enzyme, and could retain its activity in the presence of concentrations of PSME as high as 350 ppm. Lyr demonstrated that PSME was transformed and presumably detoxified by active laccase.

Physiological studies of laccase have shown that changes in substrate components significantly influence rates of laccase synthesis and duration of lag periods to optimum enzyme activity (Bocks 1967, Fåhraeus 1952, 1954, Fåhraeus et al. 1953). Similar results were reported for other extracellular enzymes (Bucht et al. 1968).

The following fungi were selected for the experiments; of the 2714 fungal isolates from lodgepole pine in Alberta, they were isolated in this order of frequency: Peniophora pseudo-pini Weres. and Gibson 29.8%, Coryne sarcoides (Dicks. ex Fr.) Bon. 23.5%, Tympanis hypopodia Nyl. 15.2%, Fomes pini (Thore ex Fr.) Lloyd 2.9%, Stereum sanguinolentum Alb. and Schw. ex Fr. 0.4%, Coniophora puteana Schum. ex Fr. 0.4%, 24 other species 24.8%.

The effect of these fungi on the four main heartwood phenolic substances was studied as follows. Heartwood meal was sterilized by soaking in acetone. After removal of the acetone, aqueous homogenates of pure cultures of the test fungi were pipetted onto heartwood meal in sterilized french square bottles with screw tops. Cultures were killed with acetone at 2-day intervals, up to 14 days. Phenolic substances were extracted in a Soxhlet apparatus, separated by means of thin-layer chromatography, and measured by means of ultraviolet spectroscopy in the case of the stilbenes, and by means of visible spectroscopy after complexing with bis-diazotized benzidine in the case of the flavanones.

The results of spectrophotometric analyses revealed two types of fungus effect. Effect on concentration was revealed by decreases or by increases followed by decreases in optical density values, and effect on molecular structure was revealed by shifts in maximum optical densities.

Two of the most common fungi, P. pseudo-pini and T. hypopodia, found in the stems of living lodgepole pine, also effected the most rapid decrease in concentration of PS, PSME, PC, and PB in lodgepole pine heartwood meal.

The six test fungi showed three mechanisms of transformation of PS. Two laccase-producing ascomycetes, C. sarcoides and T. hypopodia, caused a decrease in optical density as well as a maximum absorption shift of PS from 310 mu to 300 mu. This shift could be related to the appearance of a new compound which absorbed at 300 mu.

Three laccase-producing red-stain and white-rot fungi, P. pseudo-pini, S. sanguinolentum, and F. pini, did not effect a maximum absorption shift of PS, but red stain formation in infected heartwood meal could be related to a decrease in its PS concentration.

C. puteana, a brown-rot fungus which does not synthesize laccase, effected a maximum absorption shift of PS from 310 mu to 320 mu. This shift could not be related to the appearance of a new compound in these experiments. C. puteana could not cause a decrease in the concentration of PS in the infected heartwood meal.

Within 14 days of activity, P. pseudo-pini and T. hypopodia decreased PC to less than 10% of PC concentrations in healthy heartwood, and PB concentrations to levels too low for spectrophotometric analysis.

A series of bioassays were conducted to study phenol effect on fungi grown on different media. The three types of media used were 2% malt extract agar representing the traditional bioassay medium, 2% malt extract agar enriched to 1% cellobiose, and 2% malt extract agar enriched to 10% heartwood meal.

At 200 ppm, no significant PS effect could be observed on C. puteana, P. pseudo-pini, and F. pini cultured on 2% malt extract agar enriched to 10% heartwood meal. This concentration is lethal for the last two fungi, and is four times the lethal concentration of C. puteana, on the standard bioassay medium. P. pseudo-pini and F. pini survived 400 ppm of PS on 2% malt extract agar enriched to 10% heartwood meal.

A functional role of the flavanone PC in laccase synthesis or activity was indicated in the standard bioassay medium, 2% MEA. A concentration of 200 ppm of PC added to the lethal dose of 200 ppm of PS resulted in delayed and reduced growth of both P. pseudo-pini and F. pini.

The results of these experiments suggest that rates of stilbene-sensitive enzyme synthesis on natural substrate are sufficiently high to cope with inhibitory phenolic substances. In the case of the laccase-producing white-rot fungi, rates of laccase synthesis and activity are sufficient to transform the four phenolic substances in lodgepole pine heartwood meal. It is clear that results of bioassays conducted on 2% MEA, cannot be extrapolated to the natural substrate, but must be considered artifacts.

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PANEL II. ECONOMICS OF FOREST DISEASE CONTROL

Keith Shea, Moderator

## RISK, UNCERTAINTY, AND FOREST DISEASES

Donald F. Flora

Propagation of trees for commodity purposes is widely considered a brave and foolhardy occupation, fit mainly for corpulent corporations and foggy Federal foresters. Nobody else can afford the risks.

"Aha," you say, "Here is a speaker who will deny that folklore, and remind us of how handsomely investments in exciting conservation activities like disease control can pay off." Not on your sweet bippy.

True, I've argued that many decisions made by forest managers need not be influenced by consideration of riskiness because such decisions involve choices between action alternatives whose time dimensions are more or less equivalent. And I've talked a lot about the "allowable-cut effect," which reduces the time lag between forestry expenditures and timber income. Beyond that, I know that most deliberate owners of productive forest land believe in a future economic world in which forest products will be ever more valuable. When dollars are being laid on the table, investors' "gut" opinions, conditioned mainly by past economic events, carry more weight than foresters' uncertainties.

Nonetheless, an objective review of timber growing as a business would leave any decision theorist shaking his head. Here's why.

Forestry, whether public or private, is, in the main, a gamble. If wood were an indispensable raw material, in short or fixed supply worldwide, the outlook for timber-growing economics would be bright indeed. But in fact, the major uses of wood have substitutes whose entry depends on relatively minor changes in technology, prices, or consumer tastes. Wood is probably one of the most abundant raw materials worldwide--more widely distributed than gravel. And we face the terrible economic fact that an abundance of wood fiber is produced without any human effort whatever--we can't keep the trees from growing.

One hears that trees of the future will be more valuable because of their uniformity. But as investors we want our trees to be different. The only valuable stumpage in the world commands its premium because of uniqueness of technical quality, appearance, size, or location. If all 6-year-old trees looked alike, the market for Christmas trees would be nil! As forestry investors we must correctly anticipate the economic niche into which will fall our trees, on our land, harvested at the time preordained by our regeneration decision. If

we're right, forestry can be an attractive private and public activity. Guess wrong and we may misallocate resources unredeemable for a dozen decades.

The need to guess is what makes forestry a gamble; we have to guess because of the long time periods involved. To help reduce the guessing required by land managers, forest economists with the Forest Service have periodically estimated long-term trends in timber supply and demand. I'll review briefly how disease impacts have been recognized in such studies and raise some questions that you must answer.

I'm sure you're all acquainted with the most recent national appraisal of the timber situation. Called "Timber Trends in the United States," it was published in 1965. Included are estimates of tree mortality by State and, for groups of States, by cause delineated as fire, disease, insects, other, and unknown. This is the source of the famous statement that there are 13 billion board feet of mortality in the West, of which 7 are in Washington and Oregon. The estimates were for 1962, but they were based partly on long-term annual average catastrophic mortality.

Those figures, estimates though they were, were difficult and costly to derive. And in my opinion they haven't been very helpful. As indicators of an untapped timber supply they are deficient because they don't show accumulated mortality, nor do they indicate whether mortality is available in concentrations required for feasible logging, nor do they show what conditions the trees were in when they died. As guidance for allocating research or control effort among causal factors, they are misleading because they don't include nonkilling growth impacts nor reductions of vigor that invite other killing agents. For regional land managers they do not show how much loss was offset by salvage logging, or by redistribution of growth to the unkilled trees.

Perhaps the most important use of mortality information--indeed all information on disease impact-- in "Timber Trends" was the impact assumptions used in projecting future timber growth. Unfortunately, disease impact was not considered specifically, implying an assumption of no change over time.

Last week we issued a comprehensive resource analysis covering lands containing two-thirds of the timber in the West. By Brian Wall, the report is called "Projected Developments of the Timber Economy of the Columbia-North Pacific Region." Projections of timber availability are made, as well as timber-related economic activity. None of the forecasts recognize changes in the importance of disease losses, simply because trend information on this subject is not available, and disease experts are reluctant to make guesses.

Recently we completed the "Douglas-fir Supply Study." How did disease impacts figure in that report? Not much. Purpose of the

study was to estimate long-term timber output from National Forests under various management intensities. None of the alternatives explicitly recognized diminishing disease impact over time. Growth and mortality estimates were based on normal yield tables for unmanaged stands and on empirical information--growth of the fastest growing half of all inventory plots--for managed areas. This raises an interesting question for disease analysts: what is the history of the best half of all inventory plots as regards disease? Are these stands the noble victors of an intermittent battle, unscarred by periodic onslaughts? Or are they in fact the battered but best survivors of epidemics that affected every tree? How many exposures, to what kinds of agents, have there been? In short, how much does past empirical experience differ from the growth behavior of tomorrow's managed stands?

We don't know, of course. And no matter how inexact our knowledge of the potential behavior of undiseased stands under management, my impression is that we have even more uncertainty about the probabilities of exposure to and impact from pathogens.

I speak of uncertainty and probabilities. To decision theorists, these words have very different connotations. A statement about the probability of exposure or disease loss implies statistical evidence drawn from experience. Uncertainty is usually associated with an absence of statistical data; there is no relevant experience on which to draw.

Now, if forestry is indeed a gamble of sorts, long-range estimates of timber demand and supply will continue to be an important means of reducing the uncertainties of the business. Which raises a challenge to those interested in disease control. Shall we continue to ignore in such forecasts the likely impacts of pathogens, and potential improvements in control? To do so implies, first, more uncertainty than I think is necessary about disease impacts; and, second, little confidence in the potential success of your work. The alternative is to "go out on a limb," an uneasy position for most technical people, and give professional attention to converting one of the greatest uncertainties of forestry into quantifiable risks.

As I see it, there are four parts to the job. One is to estimate the probable impacts of individual diseases on trees, stands, and regional aggregates of stands. I'm much impressed by your work in this area, at least if it is exemplified by Toby Childs' and Keith Shea's bulletin on disease losses in Pacific Northwest forests. A second part of the job is to extend such work into estimates of impact reduction under various levels of investment in control and with specific assumptions about the probability of success in research and control. Third--and this is part of the same job--I wonder about jurisdictional disputes. Are studies of interactions between diseases, insects, and silviculture falling between the chairs? Perhaps such studies aren't needed; I would guess otherwise. Finally, the uncertainties of exposure to all killing, growth-reducing,

and quality-reducing insects and diseases must be converted to statistical statements of probability. How likely is a managed stand to be invaded during, say, its third decade? How much flexibility, in terms of extra stocking, must be maintained to meet this risk? What are the implications for successive decades of management and exposure? What are the best strategies for coping with catastrophic as well as endemic losses, irrespective of cause? What are the implications of such strategies for long-term regional timber supply?

These jobs carry no little urgency. Within two years we will be preparing another National Timber Trends document, founded on regional estimates of long-term timber supply. Shall we again implicitly assume that long-term gains will not be made in meeting disease problems?

The other day our Station's Director, Phil Briegleb, commented on inadequate statistics on unemployment as follows: "When we don't really know, we can (1) be an optimist, (2) be a pessimist, or (3) find out."

Obviously, we cannot know for sure how successful our research and control efforts will be. On that matter we are forced into optimism or pessimism. But I submit that more can be done toward quantifying the aggregate effects of disease on long-term timber supplies. And I suggest to you that it may be more important to the land manager facing the forestry gamble to have you develop quantitative forecasts of disease impact than to have you devising ways of reducing impact!

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## DOLLARS AND DISEASE

C. H. Willison

The protective function of forest land can be either custodial and negative in concept, or it can be positive. There has built up, as you well know, a great body of technique, both administrative and physical, in protecting the forests from fire. This has developed around a five-way idea of

1. prevention, removing risk through public information campaigns such as the Keep Green movement,

2. hazard reduction, removing hazard to the extent that it can be,

3. pre-suppression, developing an organization and equipment to be ready in case fire starts,

4. detection, determining and locating a fire immediately upon its beginning, and

5. suppression, the great body of fire fighting technique for use after a fire starts.

The basic idea of detection and suppression is to combine all forces to stop the fire as soon after its inception as possible.

A considerable body of scientific information and protection skills has been built also for protecting forests from insects. This can be viewed in a somewhat parallel approach. The prevention consists of logging methods which remove susceptible trees and try to leave a minimum of food and breeding grounds attractive to destructive insects. The prevention in this case can be considered a part of pre-suppression. Another factor in pre-suppression is the legal framework of federal and state law, setting up the machinery for coordinated effort on insect control when anything does break out. The detection is reported through the forest pest committees of the states and regions, held together by the annual detection flights which accomplish aerial surveillance for locating insects and other types of pests besides the insects. The suppression consists of intensive salvage and other cutting to remove susceptible trees before they are attacked, as well as elaborate spray programs which are effective against selected insects.

In tackling the matter of protection from disease, let us search to see if there is a parallel with the control of fire and insects. To begin with, however, we first have to recognize what range of pests we are dealing with in disease. There are:

1. the wood rots, which in essence reduce volume but do not necessarily kill the tree,

2. the root rots which may go into the tree to reduce volume but where our concern is primarily killing of trees or the weakening of them so they become prey to windfall,

3. the many rusts which produce cankers and galls, and the mistletoes; these, like root rots, may kill the tree or may merely weaken the stem so it is susceptible to windbreak, and

4. the various needle blights and other diseases which affect the leaves or needles to result in death of trees and stands.

Means of prevention have been developed in a very few classic instances. Ribes eradication to prevent spread of rust on current and consequent infection of white pine by the blister rust is, of course, the best known. Plant quarantines are another means to prevent spread of disease. At least in the west, pre-suppression has not been developed. However, the administrative machinery which now services insect problems can be legally expanded to serve disease as well. Detection is already provided on a very broad

scale by the annual aerial detection flights handled through the various Experiment Stations and the resource survey. Control, once a tree or stand is infected with the disease, as far as the present state of the art is concerned, is limited to action of individual timberland managers.

What can we do about the several kinds of diseases? The wood rot fungi require no outlay for control. The regular process of management steadily reduces these diseases as major factors in management. In clear cutting the older stands, the forest is converted to younger timber types which receive less exposure and have less time to develop the wood rots. Also in thinning of the young stands, any badly defective trees or ones damaged in logging are removed in the series of cuts. In Crown's northwest tree farms we can pinpoint the time when we will be relatively free of this problem. On two tree farms there is no old growth, on two more it will be harvested in six years, in two more in ten years, and in only one will it last for seventeen years.

The root rot infestations are partly taken care of in the same way. Wherever there are foci of Poria weirii, trees which show infection because of shortened needles are cut as each thinning cycle is completed over the land. The other major root rot, Fomes annosus, does not yeild itself as readily to management control. However, I anticipate that we will adapt procedures similar to those developed for the same root rot in Southern pines, namely to treat the stumps in thinning cuts as the trees are felled. There is as yet no indication from research in the Northwest that any type of sterilizing agent will be effective in neutralizing the infection which is carried over from the old growth and into the young growth stumps and roots.

In our own Crown lands in Oregon and Washington, we have not yet been subject to any of the tree killing diseases. Mistletoe, while quite prevalent in the stands of old growth hemlock, is effectively dampened when the over-mature old growth is removed. Even though there may be a few infected understory trees escape the yarding, the new stand rapidly overtops them. With short rotations in the offing, it is unlikely that mistletoe will become a major factor in slowing growth in the even aged stands up through 50 and 60 years of age. Some men advocate burning the slash in order to remove any understory infected hemlock. Our observation is that the suppressed trees 10 to 20 feet in height which may well be infected are either scarred or knocked over in the yarding, or are rapidly overtopped by the vigorous new seedlings and become of no consequence in the future stand. We are watching this, however, to find out if this observation is correct. In ponderosa and lodgepole pine the situation is different.

In the east side timber types, mistletoe is the major disease problem. The economic factor involved here is one of principle of annual cut. At the present time we believe that the manager should remove all of the infected overstory on those acres where mistletoe is a major item.

The cut on the rest of the lands should then be determined on their productive capacity. In this way the total take would not be reduced in order to make up for the current lack of production from the mistletoe areas caused by reduction of their merch growing stock.

In the strategy of management, the stress must be laid on the positive note of prevention, rather than the negative aspect of salvage. Our present management objectives include frequent thinning both on cat and hi-lead ground. The cutting cycle runs from two years in very young stands, 30-40 years of age, to five years. But even with this short a cycle, there is a degrade in quality and some loss in volume if a dead tree stands or lies three to four years before it is salvaged. Therefore the reason for placing stress on prevention.

Much of what we can do in the woods is concerned with what is called in other areas "preventive maintenance," making repairs and replacing parts before they break in order to decrease lost time and minimize repair cost. The costs of this approach are not spectacular but there are some expenses involved. For instance, logging scars on hemlock are a major source of infection in the managing of young timber. Investigation to date has indicated that damage to the roots or base of the stem are much more likely to be infected than are scars higher up on the stem. Cable yarding, with the leading edge of the logs pulled up off the ground, produces some stem damage but it is generally higher in the tree. If infection by Fomes annosus in logging scars becomes a major factor under intensive management of young stands, it may be necessary to go to high lead yarding methods rather than ground lead methods wherever possible. On the other hand, we are developing a procedure of felling the trees on yarding trails and building a narrow trail. This preparation of yarding trails followed by corridor thinning may well reduce the amount of basal damage done by ground lead methods of yarding.

For instance, we can calculate the cost of changing from cat to hi-lead yarding. The cost of yarding logs to roadside with cat or wheeled vehicle in young stands may be $5.50 per cunit. A change to cable or hi-lead yarding may increase the cost to $8.00. In a cut which removes 10 cunits, the logging cost will be $25.00 per acre. This 40-year-old stand is growing 4 cunits per acre per year. The next cut will be in 4 years. It costs us $25.00 to insure that the 16 cunits grown in the next 4 years, plus the 40 cunits residual, are not infected with wood rot. This amounts to nearly 50¢ per cunit. About the same cost will be incurred again in the next thinning cut. Is it worth an added cost of 50¢ per cunit at frequent intervals to insure that we do not get infection from this source? We don't know. We know we can remove the badly scarred or infected tree in the next cycle. This may be better business management.

In prior years the traditional management philosophy held that the plans should allow for losses to fire, insects and disease,

and the cut should be reduced from the desired amount to allow for these losses. This appears to me to be totally untenable under today's economy. We cannot predict when or in what age stand any disease, insect or fire is likely to occur. Therefore if the cut is reduced by a safety factor, the growing stock, or inventory, increases. Then when a kill occurs, whether by disease, insects or fire, the only result is that the loss is greater than it would have been under full management. Thus a safety factor for disease would engender an unwarranted cost both in reduced income because of a lower cut, and a higher physical loss when the problem occurs. There is only one way to manage a forest - right up to maximum cut all the time. If we don't cut it, we lose it!

To conclude with the idea of "preventive maintenance," I'll coin the term "preventive management" as the positive expression of the preventive function of management. To do preventive management we need from you men some new tools:

1. Way to eliminate mistletoe from otherwise healthy reproduction - in a one-shot treatment - cost not over $15.00 per acre.

2. Way to sterilize the ground where Poria weirii holes have started so the infection will not spread - cost not over $25.00 per acre.

3. Determination of whether or not Fomes annosus is a serious infection risk in hemlock stumps cut in thinning. If so, we need a way to prevent infection of stumps in partial cutting - cost not over 10¢ per stump. (Cut 10 cunits - 40 trees - $4.00 per acre.)

4. You name it.

As you men forge us these and similar tools for use in "preventive management," we'll move a bit faster into intensive timber management.

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## PANEL III. FOREST PATHOLOGY IN A CROWDED WORLD

Donald M. Knutson, Moderator

### INTRODUCTION

Donald M. Knutson

Human numbers are rapidly reaching an ultimate magnitude. About 10 years ago, Dr. Rock of the Harvard Medical School proposed that tens of thousands of our best scientists be placed to the work of developing cheap and effective methods of population control. "Pull them from whatever they're doing, because unless we're completely successful in controlling population, what they're now doing will be irrelevant."

This sense of irrelevance is expressed today by a wide tide of reactions including the despair of young dissentors, declining enthusiasm for military adventures, and a sense of futility among us scientists.

This collision course of a very finite resource base and an infinitely expanding population only partially can be altered by increasing the efficiency of resource utilization. Yet as foresters and forest pathologists, we must accomodate that fact, since our science is involved in deriving greater utility from our renewable resources.

This panel will probe a few areas where the population pressures are affecting forestry with some possible effects on our profession and our methods of solving resource problems.

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### THE FUTURE OF RESEARCH IN FOREST PATHOLOGY

B. J. van der Kamp

It goes without saying that in order to be effective as forest pathologists we must anticipate future developments and problems. The time lapse between the recognition of a problem and the formulation of a satisfactory solution is simply too long to wait until things become urgent. We must look into the future, an activity which -- to use a favorite expression of an old professor of mine -- is fraught with peril. Nevertheless I shall stick out my neck and persevere. I would like to speak about the relationship between future developments in forest land management and forest pathology, and secondly about the function of forest pathology and the competition for research money between forest pathology and other fields of endeavor.

It seems to me that forest pathologists should be mostly concerned with wood production. By this I do not mean to minimize other aspects of forest land use. Of course, recreation, watershed, grazing, etc. are important, and will probably become more so. But on lands used almost exclusively for such purposes, tree diseases are of no great consequence. We must not let our training carry us away. Dead or diseased trees are not always bad. They form an integral part of the ecological community. Apart from protection against diseases on some high use recreational areas, and private recreational lands, and protection against possible very widespread and severe disease outbreaks, forest pathologists should be mainly concerned with timber producing lands.

Having narrowed our attention to wood production, it is at least a little easier to look into the future. The key word here is mechanization. Few industries are as backwards as the forest industry in their handling of materials, especially at the logging end of things. I do not believe that present practices involving a lot of unpleasant manual labour will persist indefinitely. Rising labour costs, difficulty of retaining a satisfactory labour force, and increasing competition from alternate products will eventually force wood out of the market if changes in production are not instituted. The sort of mechanization that I consider to be inevitable is the introduction of some form of whole-tree harvester, such as is now being developed in the Eastern Canadian boreal forest and elsewhere. Such mechanization requires certain stand characteristics such as uniformity of sizes and spatial arrangement, and relatively level terrain. This last factor is of paramount importance in the Pacific North West. Much of the terrain around here is unsuitable for completely mechanized logging because it is too steep, rocky, and broken up. This factor plus increasing pressures for other uses such as recreation, watershed, and landscape, lead me to believe that most of the high elevation mountainsides which are presently being harvested will never be logged again. Management for wood production will be concentrated on only a proportion of forest lands, possibly only about one half to two thirds of the area presently classified as productive. On this highly productive area we will see intensive management, not necessarily along time honoured European lines, but intensive in terms of capital invested.

Now we can come back to forest pathology. If the above analysis is correct, we ought to concentrate on the disease problems of the low elevation, highly productive areas mentioned above. Our first task, and one which must be tackled now is to determine what these problems shall be. Root rots are almost certain to be one, but there may be others. This is the time to find out and to initiate research aimed at control. This brings me to the second point that I wish to make, and this is, to put it simply, that research in forest pathology can only be justified by the practical results that are produced. Research must be aimed at the development of

economically feasible preventive and control measures, preferably in the rather short term. Forest pathology is not a particularly glamorous branch of science. The public fancy is caught by space exploration and molecular biology, and this in turn influences the flow of tax money in support of these fields. Research in forest pathology cannot be wholly justified by some vague promise of possible future benefit, but by the development of effective control measures in the forseeable future.

During the last decade there has been a tremendous expansion in research expenditure in almost all fields of science; an expansion supported and fuelled largely by tax money. The average increase has been of the order of 10 to 15 per cent a year. Research in forest pathology has seen its share of this prosperity. It is obvious however that such expansion cannot continue indefinitely. If these rates of expansion are extrapolated into the future, the amount of money spent on research will soon exceed the GNP. In the long run, the increase in research money cannot exceed the average growth of the economy for long. The expected reduction in the rate of growth of research expenditure has now started. Inevitably this has resulted in increased competition for the money available between all the various agencies involved in research. The pinch is being felt now, particularly with us in Canada. Here is where the importance of productive (in the sense of resulting in practical and economic preventive and control measures) research comes in. As I said before, forest pathology isn't exactly a glamorous branch of scientific endeavour. We cannot rely on public sympathy and enthusiasm to keep us supplied with the money we would like to have. We can only justify our existance with the results we produce. Now I don't want to become involved in a basic versus applied research argument. By the term productive research I do not mean either of these, but rather the kind of project which is aimed at the solution of a practical problem, and in which both 'basic' and 'applied' problems are formulated and attacked as necessary. But research should never become an end unto itself; nor can the value of a project be evaluated on the basis of the number and quality of the papers produced. It will become increasingly harder to justify time spent on taxonomy, or the elucidation of life cycles of relatively rare fungi.

All this inevitably leads to a change in emphasis in our research projects. This change has of course begun already in the last few years. But from what I have seen, such an official change is not enough. We all know how easy it is to give a pet research project some practical value, and to continue as before. What is really required is a change in the attitude of the individual researchers. We must always have the practical end of our work in mind, and be on the lookout for new ideas and solutions. Only in this way can we hope to obtain the financial support for our work, and thus perform a useful function to the benefit of the community as a whole.

# MATHEMATICAL MODELING IN FOREST PATHOLOGY

Mary Ann Sall Strand

Mathematical modeling is not a new technique in biological research. However, it has not been used extensively in forest pathology. I plan to discuss some basic examples and to explore some of the implications which mathematical modeling and specifically systems simulations hold for forest pathology.

A model is simply a thought concept of a real situation. In common speech there are two uses of the word model: first the artist's model and second the model airplane. The former sense is used by physicists when they refer to model systems. Here model is an idealization of reality. Biometricians use the latter sense "the model airplane" where a model is an approximation of reality. In most scientific investigations the primary form is the word description of a phenomenon. For further analysis it is often necessary that the description take the form of mathematical statements. For example in word description we may say that the number of spores trapped decreases as the distance from the fruiting body increases, but to make further statements about the rate of decreases or to predict the number of spores which would be found 10 feet from the source we must develop a mathematical statement relating spore number to distance. You may recognize this as a regression model.

Since as pathologists we work with biological systems which are dynamic phenomena of great complexity, most mathematical models must be based on highly simplified and hence unrealistic assumptions. Even the first step in construction of a model which is the definition of the aspects of the system to be included in the study constitutes a process of simplification in itself. The process usually attempts to leave the essential elements of reality intact while removing some of the distracting details. The addition of unreal assumptions is often necessary either to remove aspects where data gathering would be impossible or to prevent the mathematics from becoming too difficult to handle. There is no single, best, all-purpose model. In particular it is not possible to simultaneously maximize generality, realism, and precision (1). These drawbacks do not however preclude the usefulness of modeling as a technique for approximating reality; they do force us to be judicious in our selection of a model for a particular purpose.

Probably the main uses of mathematical modeling lie in description and prediction. Structural models may be made such that specified parameters characterize a system; then information may be collected to estimate these parameters. For example we may wish to know how the number of seeds produced by a female dwarf mistletoe plant is related to some aspects of its size. This relationship may be modeled as a function which includes

the parameters of interest and may be estimated by the use of statistical techniques. In another case one may wish to plot the outward progress of a root disease from some focus of infection. Here infection is a function of distance. Operational modeling is used in this case, since we are describing how a process acts through time. These two types of modeling structural and operational are not new to most of us. What is new and exciting is the technique of systems simulation. This is the culmination of modeling procedures where many submodels are incorporated to artificially reproduce the action of some larger process.

Plant pathologists have developed simple models for crop epidemic simulation. Van der Plank is a notable in this field. His models are deterministic; this means that all important variables are defined while other modifying factors are assumed to be of negligible importance. The use of these methods implies for example that new infections are determined completely by the amounts of inoculum and susceptible tissue and by the infection rate (2). No unrecognized environmental factors, biological processes, or elements of chance are assumed to be involved in the formation of new lesions. Since all variables are taken to be defined, confidence intervals and probability statements need not be made. In many situations these models are adequate. Agricultural pathologists usually are dealing with large populations of genetically similar individuals growing in relatively homogeneous and compact areas. Variation from plant to plant is minimized.

This sort of modeling is usually inadequate for forest pathology. The forest pathologist is faced with large areas where great diversity of conditions exist.

A multiplicity of detailed causes may operate to produce an event such as the infection of a branch by a dwarf mistletoe seed. It is impossible to characterize all of the influences. They may range from rainfall velocity, weight of snow on the branches, to fungal infections, local bird habits, wind strength, and so forth. For economy of thought it is often necessary to ignore these and appeal to the operations of chance for their prediction, concentrating on the more important and measureable factors. For simulation of most systems encountered in forest pathology stochastic modeling must be utilized. In this technique many small influences are taken into account as unpredictable variation within the models. A stochastic (i.e. random) element is incorporated into the deterministic modeling. In practice to produce the effect of chance occurrence random numbers are chosen from a random number table and used in the simulation. The introduction of this element enables us to construct confidence limits and probability statements concerning the results of the simulation. This type of simulation attempts to reproduce mathematically the action of some process by the combination of submodels which describe and predict the actions of major aspects of the system and chance which accounts for the results of many minor influences.

In my work I am concerned with a simulation of a dwarf mistletoe epidemic on ponderosa pine. To illustrate the process of building such a model I will briefly outline some of my endeavors. First one must understand the system well enough to write down word statements which describe generally the various aspects involved. These we wrote out as a list of critical stages of the epidemic. Next a structural model is defined and limits are set. In our case we decided what the population would consist of and how to define them. We let each tree in the study be a population of suscepts represented by the needled portion of the branches. A second population, that of the female mistletoe plants, was also defined on the trees. Various relationships within and between these populations are now required in order to characterize the dynamic aspects of the system. Operational models are developed to describe the changes of the trees and the mistletoe plants with time. Some of these relations (e.g. infection) will take the form of probability models, others may be purely deterministic. At this time the flow chart has been developed (see figure 1). Computer input into the simulation will take the form of a stand map where spatial relationships between trees will be given, an array of the branchlet populations for each tree going whorl by whorl, and an associated array giving the pertinent information about the female mistletoe population on each tree. The first step in the simulation will simply be the rearraying of the populations defined for the trees. We will consider time to equal one for the first year. Time will then be incremented by one year (an arbitrary upper time limit is set greater than one) since the upper limit of the study has not been reached we will proceed to the updating of the tree structure submodel. Here the growth of the tree in terms of its branches will be simulated for the first year. Operational models including birth, death, and aging processes will be used. Next the mistletoe plant populations will be updated by reproducing the changes expected for one year. Here models concerning plant growth and seed production are used. The last phase of the simulation for the one year is the infection establishment submodel. The process of seed dispersal and seedling survival will be estimated. The new populations for each tree will be arrayed, time incremented again, and the cycling through the simulation pattern begins once more. The process continues until the arbitrary upper limit is reached; then the final arrays for each tree will be printed out. We must now call upon the speed and capacity of the computer for evaluating the multitude of relationships which must be generated for the simulation. Ultimately we hope to be able to input any stand condition with any level of mistletoe infection and project an estimate of the infection level years hence. At the present time, however, constructing of the systems model forces us to specify, if only crudely, all of the relevant relations among the elements of the studied model. This process is of tremendous value to the conduct of the investigation even if the models never manage to provide good prediction.

Horsfall and Waggoner discovered in their simulation of an epidemic of Alternaria on tomatoes that much work had been done in this field but, the basic problem of controlling the epidemic had not really been attacked. They put together many people's efforts and did a few cross connecting experiments. The results were remarkable. Their program could mimic known epidemics and by varying certain conditions could show how the course of the epidemic would have been. Optimum spraying schedules were produced and great steps made toward control of the disease to prevent epidemic outbreaks (3). Similarly my work with mistletoe will attempt to simulate the intensification of an infected area with time. This program when perfected could be used to test management alternatives. Thinning and pruning schedules could be evaluated.

Mathematical modeling has many applications in forest pathology. The careful asking of questions and use of statistical techniques is of proven value. Mathematical statements are often needed for the description and prediction of many aspects of our work. We can describe spore dispersal patterns by the relationship between the number of spores trapped and the distance from the source. The time when a particular tree may become infected can be predicted by the equation relating spread from an infection focus to time. Many such models may be combined for use in simulations. When a simulation is generated, it can be used to evaluate critical factors of a system. By testing the results against real data, we can evaluate our information deficiencies; new experiments may be suggested, new questions asked. Mathematical modeling and specifically systems simulation then are valuable tools for describing pathological problems, but also offer practical application in the testing and evaluating of management recommendations for disease control.

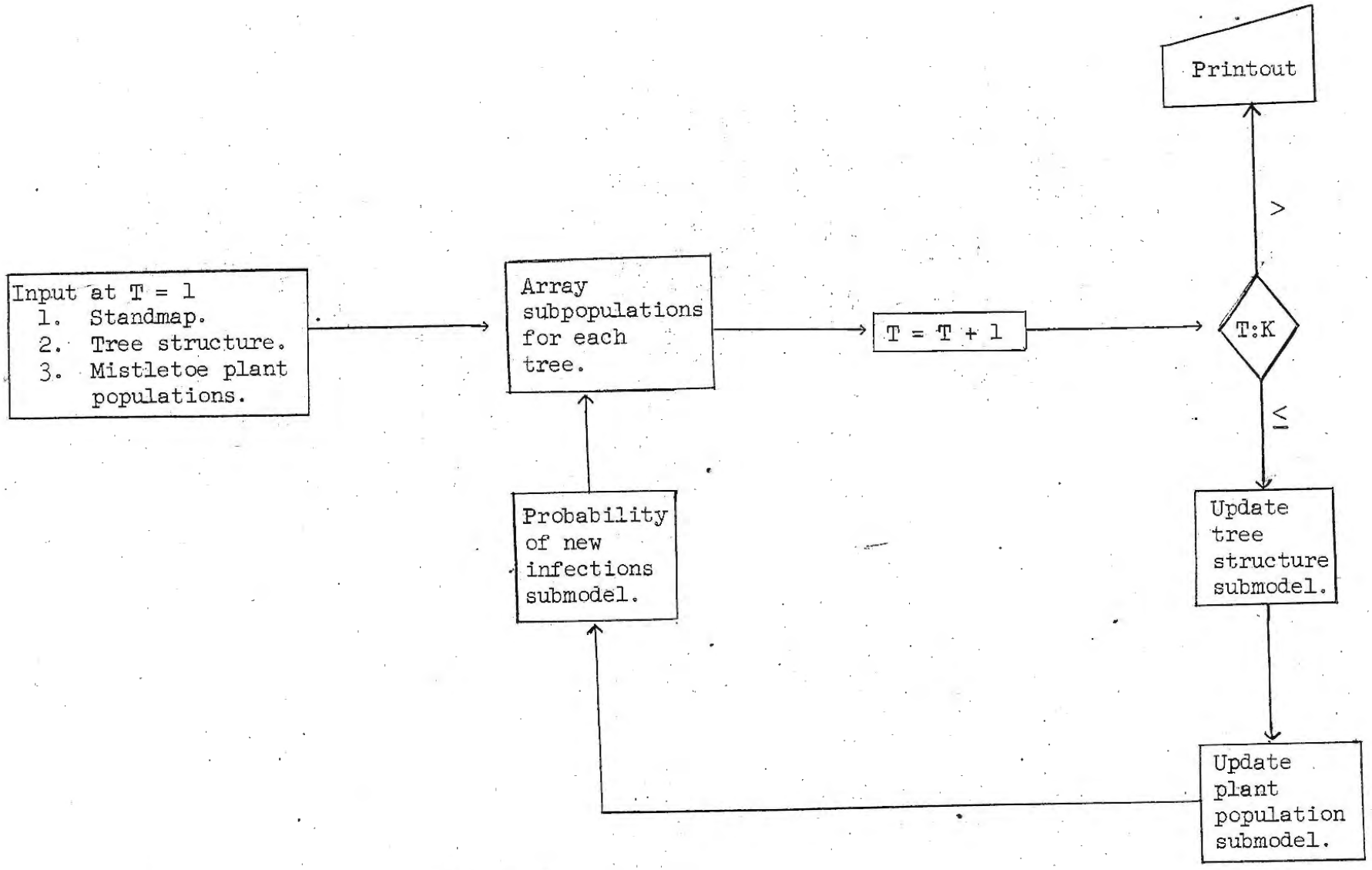
Input at T = 1
1. Standmap.
2. Tree structure.
3. Mistletoe plant populations.
Array subpopulations for each tree.
T = T + 1
T:K
>
≤
Printout
Update tree structure submodel.
Update plant population submodel.
Probability of new infections submodel.

Figure 1.

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# PEOPLE, PATHOLOGY, AND PESSIMISTIC PROGNOSTICATION

J. R. Parmeter, Jr.

California is generally recognized (except in a few remote areas dimly aware of the 20th Century) as the land of the future. What's happening today in California will happen sooner or later in peripheral regions. And what's happening in California may be cause for sober reflection on the part of forest pathologists (a dire prediction in itself).

We have tended to see ourselves as protectors of the forest for the traditional values it has. Board feet, cubic feet, cords, crop trees per acre, and similar measures of productivity, along with cost-benefit ratios and dollars per acre compounded by secret formulae into prohibitive figures, have circumscribed our thinking and left us in danger of standing with our heads in the sand (a difficult but never-the-less picturesque contortion) while the rest of the world goes by.

Traditional timber values must be considered over wide areas if we are to continue using wood (and a 100 million people from now even this supposition may be brought into question), but other values are rearing their ugly but insistent heads. Unlike Prometheus or the sea serpent, we may be turned to stone if we don't look at these Gorgons (the classic metaphors are not so much to support the exposition as to restore in some degree the failing dignity of the author).

Anyone who looks at California's forest lands gets the uneasy feeling that you can't see the forest for the people. People are everywhere. The old question as to whether a falling tree makes a sound if no one's around to hear it is rapidly becoming irrelevant, since in California the chances of a tree falling outside the earshot of

someone are becoming less and less. It is likely that the chain saw you hear is not cutting saw logs for the mill; it's cutting fireplace wood or patio blocks for the "Bide-A-Wee", the "Dew-Drop-Inn", or some other cleverly named, 35,000 dollar domicile that the Smiths' or the Jones' refer to as their mountain shack. The smoke rising from the hollow is not from a busy sawmill; it's the dump for the "Old Peoples Adult Retirement, Recreation, and Wildlife Mountain Community Center". The glow on the horizon is not a smoldering lightning strike; it's the neon signs announcing the latest, largest, and grandest mountain subdivision this side of Disneyland. What looks like a troop of mangy bears is actually a hippy commune.

And this appears to be just the beginning. It may not be too long before the economic value of forest "developments", the numbers of people owning or leasing forest property, and the pressures for skiing, hunting, fishing, camping, and hiking areas and for neon-emblazoned pleasure domes will displace traditional timber values over such large areas that we can ignore them only at our peril.

People pay the taxes that support most forest disease research. At Berkeley there are ominous portents that our research should be "people" oriented and have "social" significance. We may well argue that a sound forest industry indirectly benefits everyone, but more and more people want direct benefits from our research. The tens of thousands (it seems like millions) of small land holders, business men, and others who have a personal interest in various pieces of our forests are beginning to carry weight, perhaps more weight than wood-producers can balance.

I don't think we can continue to dismiss protective spraying, trench digging, fumigation, surgical pruning, and other expensive control measures as impractical. To the family with half an acre of mistle-toed, gall-rusted, or root-rotted pines, almost any control to preserve their little part of the forest is practical. Most of the value of their summer home, retirement home, resort, or tavern is tied to the trees surrounding it. When you multiply that half an acre by thousands, you have a sizable area demanding attention. If we don't provide that attention, someone else will. We may have to find the will and the way within the framework of forest pathology to serve both the "wood" users and the "tree" users or we may end up talking to ourselves while others fill the gap (and empty our budgets).

In recent years some of us have turned attention to control of diseases in campgrounds and high-use recreational areas. But this may not be enough. We may need to do more "extension" for the "little" man and his cabin. We may need to spend a part of our research effort on providing "squirt gun" solutions to rusts, mistletoes, cankers, needle blights, and other diseases than engender anxiety in this man. The super highways slithering all over the mountains weren't built by the taxpayers to make it easier for the log trucks; they were built to provide easier access to forest subdivisions, ski runs, camp grounds, and the like.

Prediction is risky, and I don't want to give the impression that I'm imparting learned admonitions or drawing on some secret source of wisdom. I just want to report on the direction things seem to be taking in California and to suggest that as California goes, so goes the world.

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## IMPACT OF SYSTEMS THEORY AND ORGANIZATIONS STUDYING FOREST PATHOLOGY

Donald M. Knutson

Land management, like everything else these days, is in crisis status. The problems are increasing in number and complexity. Pressures on the land are multiplying and stability of land use is decreasing. Most of these symptoms reflect the population crisis.

However, along with excessive numbers of us people, talent is accumulating, so that more mental resources are available to pursue solutions to our problems. One important avenue of problem solution involves systems theory and this is what I wish to talk about today.

I'll say a little about systems, give a few examples of application, and then, try to prove that systems theory and systems thinking will affect organizations which study forest pathology.

It's hard to tackle such a large subject in the few minutes allotted to me. If my proofs seem a bit threadbare, it's time, not evidence, that's in short supply.

We realize that problems in diverse fields have underlying similarities. Obvious is the likeness of the game of chess and the game of war. Less obvious is the similarity of the govenor on James Watts' steam engine, and the mechanism of homeostasis in vegetative communities.

The application of physics principles to life systems started principally with work by Lotka in 1924 on problems of steady state and matter-energy relations. Bertalanffy, in 1932, introduced open systems to biology and in the late 1940's, developed the general systems theory, which provides techniques for the understanding of the structure and function of communities.

What is a system?

A system is an interlocking complex of processes characterized by many reciprocal cause-effect pathways. Or, stated otherwise,

it's a well-defined set of objects with relationships between the objects and their attributes. This relatedness is the distinguishing feature of a system. It's important to remember also that a system is a mental construct. For a system to be studied, relevant elements are defined and extracted for special consideration. Two cities, A and B, for example, are elements: the highway connecting them describe a relationship between them. These elements and relationships have been selected for a specific purpose, namely, to describe the interstate highway system in a specific area. This choice of elements and relationships are relevant to that end. Unless the elements and relationships chosen are directed toward a specific goal, the number of connections and combinations would be too numerous for analysis.

So, systems theory is primarily concerned with the structure of systems, as defined by the relations which the elements of the system have with each other, the way these relations determine the dynamic behavior of the system, and with the history of the system.

The types of systems include isolated systems, where neither energy nor matter is exchanged between the system and the environment of that system; closed systems, where energy but no matter is exchanged; and open systems with both energy and matter being exchanged between system and its environment.

While the philosophy of science doesn't provide much background for a rigid definition of systems concepts, we should remember that similar difficulties were encountered with the basic concepts of matter, energy, space, and time (Bakuzis, 1968).

There are now families of special systems applications, including:

1. Cybernetics, based on the principles of feedback, or circular causal trains providing mechanisms for goal-seeking and self-control.

2. Information theory, stating that information is a measurable quantity equal to the negative entropy of physics.

3. Game theory which analyzes rational competition between two or more antagonists for maximum gain and minimum loss.

The list could include decision theory, organization theory, systems engineering, bionics, operations research, and others.

Interest in applying systems thinking to problems is widespread today. Let me read a few titles from current journals:

1. A mathematical study of the present arms race.
2. Decision trees and the Second Law.
3. A systems approach to management.
4. Stochastic models of war alliances.
5. A game for studying the problems of arms control.

These powerful tools are already deeply involved in production programs of various types. Recently I read an article explaining an entirely automated ketchup factory. Another example is the TVA power simulator, a program for more efficient allocation of power. Systems models are also used in traffic control and cargo transport problems.

In the July 1969 issue of TAPPI, there are two articles of interest; one on computer simulation of the forming process in paper-making machines, and another article which begins, "the recent trend toward systems analysis and computer control of Kraft pulp mills has emphasized the need for better understanding of relationships."

The attraction toward systems concepts as a tool is growing, largely because of the complexity of modern processes which must be understood. While classical science has been successful in developing theories to explain unorganized complexity (using statistical methods) our main concern is to understand organized complexity, and developing a general theory of organization. The laws of predictive behavior, which grew out of the physical sciences, aren't sufficient to explain such concepts as organization, wholeness, differentiation, and self-regulation, which are so important in biology and in the behavioral sciences (Bertalanffy, 1956).

With specialized science getting more so, it's harder for scientists to communicate with each other and the possibility that common governing principles operate on entirely different entities, gives us some hope of overcoming our increasing isolation from each other and from fuller productivity. The laws of gravitation, for example, unify the planetary system, the tides, and Newton's apple in a significant framework, even though they have little else in common.

So, the aim of GST is to facilitate integration of various sciences, both natural and social, by developing unifying principles.

Natural resources can also be studied as systems since ecology is concerned with the same questions as cybernetics: i.e., regulation, selection, and dynamic balance.

Watt (1968) has viewed ecology in systems terms. The chief attribute of a system, he says, is that we can only understand it by viewing it as a whole. The important systems concepts as they apply to ecology research are:

1. Breaking a program into many small parts, not a few large ones.

2. Use recurrence formulae to express the change of states over time. Since ecological studies deal with complex historical processes in which all variables change with time, this change must be dealt with in terms of recurrence formulae that express the state of the system at time t+1, as a function of the state at time t.

3. Optimization of processes for making optimal choices among an array of alternative strategies at each sequence of time.

The complexity of the relationships, both biological and physical which are part of ecosystems, arise from several sources:

1. Sheer number of variables
2. Number of types of variables
3. Number of levels of organization
4. Nonhomogenous and nonuniform distribution of entities in space and time.

Thus, say Watt, if we're to study the whole, our research strategy must be designed in terms of fitting all fragments together at the end of the research program, i.e., designing the entire research program in terms of conceptual models into which submodels, growing out of the various parts of the whole program, can be fitted in as components.

Watt breaks community analysis into four parts:

1. Systems measurements
2. Systems analysis
3. Systems description
4. Simulation and optimization

He observed a trend away from systems measurement and toward systems analysis, comparing two periods, 1920-34 and 1945-65. In the early period, systems measurements received 80 percent of the effort and systems analysis 9 percent. In the 1945-65 period, only 65 percent of the effort was spent on systems measurements while 27 percent was spent on systems analysis.

| | 1920-35 | 1945-65 |
|---|---|---|
| Systems measurement | .80 | .63 |
| Systems analysis | .09 | .27 |
| S. description | .09 | .08 |
| Simulation and optimization | .00 | .00 |
| Writing | .02 | .02 |

The main implication for ecosystem studies is that there will be a shift away from studies of biomass and energy and towards patterns and processes.

Paper, fuel, and logs have been our first goal in forestry. We've taken for granted, or ignored, the process values derived from forests--soil stability, the water cycle, weather amelioration, and others. These aren't really products, but are an output due to the nature and structure of the ecosystems. Now, in 1969, we are pressed to produce more products and simultaneously

more process values from our wild lands. We know there can be no continuous flow of products without system stability, yet we don't know how far we can further disturb our systems. We don't understand our own ecosystems well enough.

Bakuzis has examined forestry in an ecosystem perspective, and Seale has attempted to show that it's both possible and profitable to view forestry as a system, in a management sense.

Forest management is run by economic considerations with the dominant features the long-term investment and the high level of uncertainty. Forestry and uncertainty are getting more attention as pressures on resources leave less room for trial and error. Gould summarizes fifty years experience on the Harvard Forest by saying the forest response to management has not been predictable, the white pine emphasis has not paid off in the market place, and the returns on capital investment have been less than those earned by money invested in endowment funds.

He summarizes in these words, "Perhaps the most important highlights of Harvard's experience is the fact that events have turned out so differently from those on which plans were based 50 years ago. The demand and price of forest products has varied greatly, silvicultural control has been less effective than anticipated, and natural catastrophes have upset the best laid plans. These forces seem likely to continue, making our knowledge of future events so imperfect that flexibility to meet uncertainty and risk should be a central consideration of any theory devised to guide the prudent management of forest resources. To be useful, production concepts should release the imaginations of foresters to analyze the full range of possibilities and project bands of probable results. Such activities will not eliminate the final subjective evaluation of risk that must be made by financially responsible management, but they will define and reduce the areas of uncertainty as much as possible in the light of existing knowledge. Finally, the Harvard Forest case history suggests that both natural and social scientists have a great deal to contribute to the job of perfecting new and more realistic forest management concepts."

Let me summarize this part quickly, and get on to my main point.

Basic to GST is the belief in the usefulness of a synthetic approach, combining contributions from many fields in order to achieve advances which can be communicated back to specific fields. The GST must be developed by large, interdisciplinary groups, rather than by a special group of GST theorists. The real challenge is to find the proper level of abstraction in developing a general theory (Mesarovic, 1964).

Whatever the fate of the GST, the applications are widespread and the uses increasing even before the true historic prospective of GST can be resolved (Bakuzis, 1968).

Like statistics, the application of systems methods transect all lines of discipline and relies primarily on a mathematical-logical basis. As our problems are becoming staggering in complexity, the machine is gaining in problem solving ability.

Thus, while we can always "pull the plug" if we don't want the machine to dominate our lives, especially our professional lives, we most likely won't. The computer and GST are here to stay.

I have illustrated that these methods are being used to study ecosystem problems. Now I'd like to turn to the subject of systems and administrative organizations.

Systems thinking is already widely used in management. We're all familiar with PERT (Program Evaluation and Review Technique) which is basically a statistical technique for quantifying knowledge about uncertainty faced in research, production, or other activity. PERT uses a constellation of probabilities to evaluate past performances and tries to predict future evolution of events. Management can transfer funds and manpower from parts of a program that are ahead to parts behind schedule. PERT uses events as clearly identifiable points in time which mark the beginning or ending of certain operations.

Also, systems thinking is well-established in marketing aspects of business, in bookkeeping, and keeping inventories. It's profitable. The pulp industry, and the ketchup factory, for examples with top management endorsing systems thinking, will be aware that pulp-sticks and tomatoes are inputs so important to their operations that their production must be streamlined, and the techniques which have proven successful in making paper and ketchup, to stay with these two examples, will be applied to raising trees and tomatoes.

Why?

Because the successful administrators and executives, those who rise to prominence, will do so because they used systems concepts in their business, and this has meant greater production or profit. These men in turn will promote the next generation of men and women capable of mastering these powerful techniques and using them to increase production efficiencies. Eventually, high echelon administrators with a systems viewpoint will dominate industry, and eventually, government. And these people will be fluent in the terms of the day: Feedback, simulation, entropy, constraints, black box problems, information and others.

What will these systems-oriented managers think about and what will they believe?

decisions in such fields is outside the province of folk-skills or common sense. Similarly, decisions arising from conferences of management science or operations research can be evaluated only by highly skilled men. The language and methods of modern decision making is passing into the hands of an elite and highly sophisticated group of science-oriented people.

At the same time, science keeps nibbling away at the folk-culture which supports it--although, with increasing reluctance nowadays. Boulding suggests that major struggles between science and the various national folk cultures is "highly probable."

## Conclusions

I've tried to say that our profession faces problems due largely to too many people. Population control is the greatest problem today in forest pathology. In cybernetics language, we're faced with the problem of going from a positive transient state, when all is expanding, to a steady state, when growth approaches zero, and enough is enough, so to speak (Odum, 1969).

I've pointed out that our problems have common qualities with problems in other fields, and that General Systems Theory and related methodology can be used to discern these relationships between disparate things.

I hope I convince you that these methods are not only being applied to our scientific fields, but to our administrative structures as well.

I predict that the following things will occur: There will be a reduction in the number of levels of administrative command. Probably the first to go in governmental resource circles, is the forest supervisor level. With the completion of compartmentalization of forest districts with all the records stored in centralized memory units, the forest supervisor and his staff will become obsolete. Secondly, resource problems will be approached on a unit scale, a watershed, for example. Team efforts will be addressed to the areas, with team size and makeup depending on the objectives of that area and the situations which might prevent us from attaining those goals. I suspect that pathologists will be used primarily to evaluate dangers from the microbial world. If fungi represent a very serious obstacle to further wood production, the land-use decisions for that land will probably change in such a way as to minimize the role the fungus, or other microbe, will play.

Teams will be made, and disbanded frequently.

Money will be shorter, the public more hostile.

But, I think, the application of systems thinking to professions such as ours has some inherent dangers of which we must be aware.

We must avoid running at full speed and then jumping on the wrong train. The reason government is in the resource sector at all is presumably because people don't want price to regulate water quality any more than we'd want the market place to regulate output and nature of court decisions (McKean, 1958). Somehow our natural resource areas must be freed from market-place decision making. Our forests must be freed from politically motivated pressures.

One danger is that our high powered systems oriented decision makers could possibly identify the wrong objectives.

Chestnut (1967) noted that it took millions of years to develop the resources we're depleting in a few hundred years. Then he goes on to say: "...on the other hand, we are now learning at an increasing rate, to make substitute fuels, fibers and materials and to provide facilities for recreation and inspiration which can serve similar functions to those of the past. Also our rate of making these new materials and facilities is comparable to, if not in excess of, our rate of consumption."

Comforting words from an engineer.

Too, we must guard against the possibility that our science be elevated in status, but corrupted in detail, as in the Lysenko incident (Boulding).

Ultimately, the earth must bear us up. When land can't stand the pressures, either it is destroyed or protected from those pressures. In either case human life cheapens. While our profession has historically been concerned with improving the efficiency of resource production (either by increasing the acres, the production per acre, or the utilization of the products) we must, with the help of other sciences, turn more attention to the ecosystems producing these products and processes. The preservation of our ecosystem must become our primary concern.

At the present time, there are no long range objectives for our natural resources. Certainly our forests and rivers enjoy no freedom from the dictates of the market-place. Our lands can't forever accomodate more people. Our national land policies must soon reflect this truth if we hope to survive. Our land management objectives must be more clear, more comprehensive, and more secure from politics.

Most of my remarks relate to governmental agencies which own land. As for universities, I believe John Fischer in the Sept. 1969 issue of Harper's, stated it well when he wrote an article called, "Survival U: Prospectus for a Really Relevant University." He proposes that modern universities have as their objectives, "to look seriously at the interlinking threats to human existence, and to learn what we can do to fight them off." Only courses will be taught which help answer the question--also its motto--"what must

we do to be saved." He quotes a proverb from Pogo, "we have met the enemy and he is us."

As forest pathologists, I think we must be aware of Systems Theory and its applications. We should understand how to use it effectively and some of the inherent dangers.

The Systems approach will be used when our science is fitted into a task force whose urgent job is nothing less than saving the world by preserving our ecosystems--those animal-plant-earth relationships that life is all about and of which forest diseases are only a part.

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## WORKSHOP PANEL REPORTS

### GROUP I. WHAT'S NEW IN PRODUCTS PATHOLOGY

J. W. Roff, Leader

The question of "newness" was dealt with from several angles including new means of control of deterioration through biological agents or chemical applications, also the new means of measuring the results of such controls which have become available as a result of newly developed materials and electronic advances. Changes brought about by automation in production and transportation of products were discussed in relation to concepts of decay control.

Electronic techniques for measuring quality of wood can also be applied to register activity of decay organisms and thus to assess effectiveness of preservatives. Some testing of poles in service using portable field units was described by Bob Graham (Oregon). The equipment may be used in deciding need for replacement or for additional treatment with a penetrating preservative or application of biological control.

Progress was reported on the interaction of a strain of Scytilidium and Poria carbonica, a frequent cause of rapid decay of Douglas-fir poles. Results of field applications of this principal to inhibit decay in standing poles were promising.

Tony Cserjesi (Vancouver), described use of gas chromatography to measure evolution of $CO_2$ by fungi in wood in assessing decay activity in toximetric studies of preservatives.

The reaction of fungi in wood to extractives developed by the tree was discussed by Wayne Wilcox (California) in relation to possible stimulation of decay. Occurrence of wetwood and subsequent problems relating to seasoning were attributed to bacterial degradation and subsequent modification of cell constituents.

Gus Loman (Calgary) pointed up the need for a different concept of wood decays to stress the positive approach in studies. Instead of discussing losses involved he suggested more attention be given to determining how to make better use of the material which remains. Faced with the established fact of overmaturity in forests, research should look ahead of pathological rotation studies and aim to assist present operators in finding more uses for partly decayed wood.

The newness of the old in chemical control was discussed in relation to production practices, storage and shipment of wood chips and lumber. Automated systems that rely upon bulk storage of material to ensure efficiency in utilization were described in terms of the increased risk of infection in the wood which has resulted in serious economic losses.

The fact that control measures to reduce fungal deterioration in wood products were often available to the industry but were frequently ignored by the operators, was regretted by all present.

## GROUP II. RECREATION SITE HAZARD

Lee A. Paine, Leader

The workshop on recreation site pathology and hazard control was convened on the spur of the moment. Despite lack of preparation, considerable information and misinformation was exchanged.

1. According to Dick Smith (who lost his notes on the session), Paine briefly discussed the purpose and present status of the hazard research program at the Pacific Southwest Forest and Range Experiment Station.

2. Four needed research projects were specified: root disease inspection techniques and evaluation of associated hazard; development of field equipment for nondestructive estimation of decay in standing trees; preparation of tables indicating force applied to trees of various configurations as a function of wind velocity; and guides to force required to cause failure of trees with a given amount of decay. Questions were raised as to the organization that might undertake the last three and possible outside financing.

3. The relative economic importance of failure classes is not in line with the money spent on control.

4. Factors involved in hazard were specified: probability of failure; probability of target impact; damage potential of failure class; and target value.

5. Field procedures in hazard evaluation consist essentially in estimating these factors and multiplying them for a hazard rating. Control depends on whether the rating exceeds the administrative hazard control level.

6. A discussion of why available data suggest greater loss from lower bole than from butt or root failures produced little agreement, although John Davidson commented that it might result from bouncing.

7. Far more questions were raised than anyone could answer.

   a. How can we get research information in usable form to the man in the field? Research results do not easily reach the stage of field application.

   b. How can we interest administrators in taking responsibility for and actively working with programs which should be applied uniformly throughout an administration?

c. In hazard control management, how can we get the administrators to assume the responsibility for setting an acceptable level of loss to property and recreationists?

d. How can we get administration to plan ahead in making hazard and disease surveys of proposed recreation sites?

8. The relative independence of field units was seen as a major obstacle to coordinated and unified attacks on such problems as hazard control.

In conclusion, the problems involved in acceptance and uniform application of research results appear to need as much work as the research iteself.

## GROUP III. ELECTRONIC LITERATURE RETRIEVAL

A. E. Harvey, Leader

Since the workshop group lacked expertise on the mechanics and philosophy of computer programing for literature retrieval, discussion was centered on the scientist and his individual requirements for services in this area. The discussion was organized to find mutually agreeable answers to the four important questions detailed below:

I. What type of information retrieval generation is required to satisfy research needs?

Answer--Details of the citation, full title, plus a summation of at least the conclusions drawn from the work by its authors.

II. Should retrieval systems be designed to operate with total or field specific information banks?

Answer--Although a functional system operating on a total world literature base would be highly desirable, it probably is impractical and field specific systems would be adequate.

III. How should the individual user interact with the retrieval system?

Answer--Both direct interaction via an 'on line' system and single query use via a 'batch' processed system are desired. The method chosen would be dictated by the specific research problems encountered by the user.

IV. How can the cost of retrieval system development be justified and direct cost/benefit ratios be determined?

Answer--Development of rapid information retrieval capabilities provided by computer based systems for specific information areas must be justified by the economic advantage provided to those research programs that desire use of such systems. Likewise, the cost of adapting existing systems for specific problem areas must be justified by the economic benefits within the individual research program. The cost to benefit advantages and the justification of such systems can be determined by consideration of the following factors[1].

1/ Fishel, W. L. 1969. Information systems for agricultural research. Science Review 7(1): 21-30.

1) The subject area has a definite need for information that cannot be currently satisfied.

2) The information desired is based on complex subject areas, or the means of procuring the information are complex.

3) Collection or analysis of the information requires repetitive or costly methodology.

4) There is a need for recurring information.

5) Information needed must be formally documented.

6) Savings in time or cost of procurement.

7) Relative value of the information to be provided.

8) Manpower savings.

9) Quality of decisions resulting from the provision of the information.

10) Elimination of duplication.

11) Initial cost of the system.

12) Operation and maintenance costs.

13) Improvements in personnel efficiency.

In addition, the group discussed at some length the increasing need for electronic literature retrieval systems in many areas of science and technology. It was noted that several systems have been, or are now being developed which may satisfy, at least in part, the specific needs of many research projects. Among those which have been developed, Intredis, Famulus, and the University of Georgia's retrieval system are now in use. The Washington State University-Forest Service cooperative project, to develop a system for the subject area of host-parasite biochemistry, is not yet functional. A system for pesticides information, developed by the Pesticides Information Center, should be functional by the time these Proceedings appear. Many others in non-aligned fields and new projects in our own field will appear in the near future.

Our group expressed hope that computer technology is up to solving the problems of today. The future can bring only an increase in the complexity and importance of literature base problems.

## GROUP IV. SILVICULTURAL CONTROL OF DWARF MISTLETOE

J. Stewart, Leader

About the only definite conclusion that could be drawn from the workshop on the "Silvicultural Control of Dwarf Mistletoe" is that the parasite can be controlled by clearcutting. Short of this treatment, there was no conclusive discussion. It was clear that the reason for this indecisiveness is the lack of information concerning the host-parasite interrelation in managed stands. At what rate does mistletoe intensify to a damaging level in stands that are thinned to proper spacing. Comments on observations varied all the way from the trees growing so fast that the mistletoe is no problem to the mistletoe intensifying so rapidly that the trees decline.

Until this rate of intensification is better defined by species and other variables yet undetermined, the silvicultural control of mistletoe will remain an art.

# HYPOGEOUS MACROFUNGI AND MYCORRHIZAE

James M. Trappe

The hypogeous macrofungi are important to foresters and forest pathologists as ectomycorrhizal fungi. Though most common in temperate to boreal forests, some species are known from tropical and desert habitats. Only the western European hypogeous flora is well known, and even there new taxa are still occasionally unearthed. Enough is known about the western American species to certify the region as a "world center" in terms of total abundance and taxonomic diversity; new taxa are being regularly discovered, and the surface has literally barely been scratched.

## SYSTEMATICS

Wide taxonomic diversity characterizes the hypogeous fungi. In the Basidiomycetes, most species are hypogeous in the orders Hymenogastrales (with seven families and 20 hypogeous genera) and Hydnangiales (one family, nine hypogeous genera). The mostly epigeous Lycoperdales include several hypogeous species as well.

In the Ascomycetes, the order Eurotiales contains the monotypic family Elaphomycetaceae, all of whose species are hypogeous. The Tuberales (truffle fungi) are comprised of five families and 27 genera, all being hypogeous except for one epigeous and evidently saprophytic, tropical species. The Pezizales contain one genus, Geopora, whose species are hypogeous to subhypogeous.

Finally, the order Mucorales of the Phycomycetes contains the genus Endogone with several sporocarpic species.

Altogether, close to 500 species of hypogeous fungi have been described. Only the future will reveal how many others remain to be discovered: I estimate that the number will push 1,000 by the turn of the century, or even more should systematic exploration be undertaken in Asia, South America, and southern Africa.

## MYCORRHIZAL RELATIONSHIPS

The importance of studying the taxonomy, physiology, and ecology of mycorrhizal fungi has been underscored by recent research developments. The rather belated recognition that different mycorrhizal fungi can vary markedly in physiological properties, which in turn can produce differential host response, has been substantiated in numerous details by Bowen and Theodorou (1967) and numerous others.

Of specific pertinence to forest pathology, Zak's (1964) hypotheses on the role of mycorrhizal fungi in protecting host roots from pathogenic infection have been resoundingly confirmed. Marx (1969a and 1969b) and Marx and Davey (1969a and 1969b) have shown that

portions of pine rootlets infected by mycorrhizal fungi are immune to attack by Phytophthora cinnamomi. However, the several mycorrhizal fungi studied in their experiments differed markedly in production of antibiotics that could potentially protect adjacent, nonmycorrhizal parts of the root system.

These findings suggest that selected mycorrhizal fungi can eventually be enlisted as protectors of tree roots against particular pathogens. The hypogeous fungi merit our particular attention for three primary reasons: (1) many appear to be phylogenetically advanced, i.e., derived from Agaricales or Pezizales, and thus are likely to have evolved "sophisticated" metabolic systems that produce byproducts with antipathogenic properties, (2) they occur in abundance and great diversity in western American forests, and (3) they include the only ectomycorrhizal species (truffles) whose ecology is known well enough that silvicultural prescriptions can be devised for production in forest conditions.

Experimental evidence of the mycorrhizal habit is available for only a few hypogeous fungi in the Gasteromycete genus Rhizopogon and Ascomycete genus Tuber (Trappe 1962, 1967, 1969; Volkart 1964 and others). All that have been experimentally tested, however, have proven to be mycorrhizal. Detailed anatomical analyses of sporocarps and associated mycorrhizae have established the association beyond reasonable doubt for many other species (Ceruti and Bussetti 1962; Fontana and Centrella 1967 and others). In nature, nearly all appear to be obligate associates of ectomycorrhizae.

## ECONOMIC INCENTIVES FOR GROWING TRUFFLES

The truffles marketed as food comprise half a dozen of the many species in the genus Tuber: black truffles include T. brumale Vitt. and related species; white are T. griseum Pers. ex Fr. In 1968, wholesale prices for fresh truffles in northern Italy ranged from $3 per pound for low quality specimens to $90 per pound for the highest quality. According to Newsweek (Feb. 24, 1969), France in 1968 exported $3 million worth of foie gras, whose distinctive flavor depends on the truffle component. In northern Italy, peasants adept at finding truffles can double their annual income over what might be earned as farm proprietors or laborers. The importance of truffles to local economies in Italy and southern France is reflected by retail prices in America. In September 1969, a 2-oz. can of black truffles was priced at $8.60 in a gourmet food store in Oregon.

Provincial tradition and laws govern the feasibility of applying silvicultural methods to truffle production. In northern Italian provinces such as Piemonte, truffles belong to the finder, and most land is open to truffle hunting. Landowners consequently have *little incentive to invest capital in production-increasing measures.*

In central provinces such as Umbria, however, truffles legally belong to the landowner. Here, some owners of large tracts find the truffle crop rewarding enough to apply intensive management.

Numerous economic fringe benefits spin off from the growing, harvest, and processing of truffles. For example, trained dogs are used to locate truffles by scent, since visible signs of the subterranean ascocarps are rare. Specialized dog-trainers operate "universities for truffle hounds" and can sell good, trained dogs for as much as $150. Where truffles are property of the landowners, private police forces are sometimes employed to protect the crop from truffle poachers. Since truffles and fine wine go hand-in-glove, a detailed economic analysis might even show that vintage wine exports are enhanced by truffle exports!

## ECOLOGY AND SILVICULTURE OF TRUFFLE PRODUCTION

More than a century of study by southern European botanists has been devoted to truffle ecology. Until recently, this has consisted mostly of collating and confirming what has been perceived by peasants and truffle growers from diverse parts of the truffle-producing regions. More sophisticated research in mycorrhizal relationships is now underway at the Botanical Institute of the University of Torino in northern Italy.

Since truffles are obligate mycorrhizal fungi, the single most important requirement for production is a suitable ectomycorrhizal host. Members of several genera of trees and shrubs can fill this role, but Quercus and Populus species appear to be best.

In addition to mycorrhizal host, a number of other environmental factors are associated with prolific truffle fruiting (Ceruti 1968):

Soil: Shallow, on a well-drained slope
Calcareous, pH near neutral, with iron and phosphorus oxides
Low in organic matter
Some clay, but not necessarily a high fraction

Climate: Some part of the year, dry
Precipitation in July and August

Vegetation: Tree canopy less than 50-60 percent
Ground cover less than 60 percent

These conditions restrict the prime truffle-producing regions in Europe to central and southern France and northern to central Italy.

The silvicultural practices derived from knowledge of truffle ecology are exemplified at the Carlo Urbani properties on the

slopes of a narrow, Apennine valley in Umbria. With a history of two millennia of forest exploitation, such usable timber stands that the poor, limestone soil might once have produced are now replaced by brush and scrubby trees, few species of which support truffles.

A vigorous program of brush clearing by hand labor is now underway. Once the brush is rooted out and burned, the slopes are terraced to minimize raveling of the loose, stony soil. Oak seedlings raised in truffle-bearing soil are then planted in a wide spacing on the terraces. Vigilant efforts are continued to eradicate subsequent brush growth.

Having kept careful records on truffle production for five decades, the Urbanis have discovered that truffles first fruit under oak saplings about 5 years after acorn germination. Possibly the mycelium must accumulate size and energy through several years of mycorrhizal association before it begins to fruit. Truffle production begins to decline when the oaks reach an age of about 30 years when fruiting of other mycorrhizal fungi increases. The truffle fungi are hypothetically succeeded by other species as the primary mycorrhizal associates of the oak root systems. The ecological and physiological phenomena responsible for this apparent succession are unknown, but it is interesting to note that the period of change generally coincides with the onset of flowering of oaks.

Regardless of cause, tree age has an important relation to truffle production on the Urbani land. When a truffle-bearing oak reaches about 25 years of age, a few oak seedlings are planted at the edge of its crown. The old tree is cut 5 years later. The young trees are then beginning to bear truffles and can be thinned later to maintain a suitable spacing.

## DISCUSSION

An inevitable question follows this presentation: Can the black or white truffles of Europe be produced in the U.S.? Presumably they can, provided that (1) the proper habitat requirements are met, and (2) a means can be devised to establish truffle mycelium on oak mycorrhizae without importing soil or seedlings from Europe (forbidden by plant quarantine regulations).

Since forest pathologists are, by definition, people of exquisite taste, the production of truffles is bound to arouse enthusiasm. A more important, though less gastronomic, consideration for forest pathologists is what can be learned from truffle culture in terms of biological control of root disease. Clearly, the silviculture of propagating specific mycorrhizal fungi can be developed, if one has adequate economic incentive to do the requisite ecological research. Such incentive may already be present in the case of protecting southern pines from Phytophthora attack by use of

selected mycorrhizal fungi. Efficiency of root protection by different mycorrhizal fungi in nurseries also merits attention, particularly in reference to pathogens that appear on established seedlings, when soil cannot be fumigated. In the West, we would be well advised to anticipate the likelihood of yet undiscovered root disorders in young stands. The key to control of some of these may well be a silviculture aimed at promoting specific hypogeous or other ectomycorrhizal fungi as efficient protectors of the fine root system.

## ACKNOWLEDGMENTS

The American Philosophical Society and the Society of Sigma Xi joined the U. S. Forest Service in support of the author's studies on hypogeous fungi. Facilities and stimulating contacts were kindly provided by Professor Arturo Ceruti, Director of l'Istituto ed Orto Botanico dell'Universitá di Torino.

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## SPECIAL REPORTS

### TOLERANCE OF POLYPORUS AMARUS TO INCENSE CEDAR HEARTWOOD EXTRACTIVES

W. Wayne Wilcox

Abstract: Polyporus amarus, which causes brown pocket rot in heartwood of incense cedar, was grown in liquid culture containing malt extract and various concentrations of incense cedar extractives as were two other brown rot fungi, Poria monticola and Lentinus lepideus. P. amarus had a relatively high tolerance for all extractive fractions, and its growth even appeared to be stimulated by low concentrations of most of the fractions. Such tolerance may be a factor in the unusual ability of P. amarus to degrade this highly decay resistant wood. (Editor's note--this paper has been submitted for publication and consequently an abstract only is provided here.)

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### THE BIOLOGY OF PHORADENDRON BOLLEANUM SUBSPECIES PAUCIFLORUM ON ABIES CONCOLOR

Leonard S. Felix

The true mistletoe Phoradendron bolleanum subspecies pauciflorum parasitizes white fir, Abies concolor. The former occurs roughly in the southern two-thirds of California and runs into Baja California and Arizona.

The damage to white fir is considerable and in the Pinecrest area of the Sierra Nevada (Stanislaus National Forest), where the ranges of the two types of mistletoe overlap, the damage appears to be greater than that caused by dwarf mistletoe. At this latitude the upper elevational limit of the true mistletoe is about 6,200 feet.

The story of the true mistletoe begins with the deposition of seeds and quite often ends with the death of the host tree.

Flocks of bluebirds, robins or other members of the thrush family land on the tops of uninfested trees. The birds pass the mistletoe seeds through their digestive tracts and deposit them in a viable condition on the fir host. Because of the habits of birds, most seeds are deposited on branches. Some seeds, however, are deposited on the terminal leader; main stem infections result from these. As most deposition is at the tree top, the average infection is found within a foot of the main stem.

Generally a continuum is evident down the main stem of a heavily infected tree. Seeds are found most numerously within a few feet of the tree top and the youngest seedlings in the second internode

from the top. Further down the stem seedlings mature into young plants and eventually large plants. Progressing further, branch infections are partially overgrown by diameter increase of the main stem. Finally, branch infections are completely overgrown and die, their shoots ultimately breaking off so that there is little external evidence of their existence except for occasional swelling and production of small secondary shoots. Once the large dead shoots have broken off, two things have been observed to occur: (1) The cortical strands of these former branch infections often have not made a connection with the main stem and the entire mistletoe system dies; (2) a connection may have been made and long sinker systems will extend for several feet up and down the main stem; this is often the case with direct main stem infections. The depth of these sinker systems indicates that the infections began quite near the tree top.

Meanwhile, branch infections too far from the main stem to be overgrown by tree diameter increase become large and bushy, not uncommonly measuring over 2 feet across.

In addition to this predominant pattern of infection, secondary spread within a tree will result in scattered infections of various ages, centered primarily on large, fruiting infections.

After extensive shoot systems have developed in tree tops, the portion of the tree above the main mass of true mistletoe is killed by members of the bark beetle genus Scolytus. The entire tree is then often attacked and killed. True mistletoe is primarily a water parasite and a pilot study suggests that the mistletoe-infected trees are better homes for the beetles due to an altered moisture level.

Branches also die distal to large branch infections. Cause of death is unknown.

The effects of bole infections on wood quality is striking. White fir logs with long sinker systems extending along their length come off the peeler in the form of confetti. Lumber is shot-holed. Additionally, old overgrown mistletoe shoots add to the total defect. The proportion of the main stem affected by mistletoe depends on the height of the tree at the time of seed deposition. Birds prefer the tallest trees in a given area. Generally speaking, the upper half of the tree is affected.

True and dwarf mistletoes are often found in the same tree. Their endophytic systems apparently do not harm one another, even when found in the same wood.

APPENDIX I. -- NECROLOGY

JESSE L. BEDWELL
1892-1969

Born in Grand Junction, Colorado. Served in France with the 91st Division, A.E.F., during World War I. B.S. (University of Idaho) 1920. Ph.D. (Yale) 1932. District Ranger on the Weiser (now part of the Payette) National Forest, and on the Cache National Forest. After several years with Blister Rust Control, transferred to Forest Pathology. In charge of the Portland office from 1935 to retirement in 1958. Survived by widow (Lois), two daughters (Mary Eleanor and Margaret), and two grandsons.

Jess was a fine example of the conscientious public servant. Next to his family responsibilities, his first consideration was for the job. He took a personal interest in the welfare of the people in the Portland office, and his wise counsel often kept us from making serious mistakes. Although there was no doubt as to who was running the organization, he was always willing to consider other opinions, and there were no hard feelings even when our opinions differed drastically.

Jess had a good life, and a useful one. After enjoying generally good health during most of his life, he had a stroke and died in a few hours. He was a good friend, and I remember him with affection as well as respect. (Toby Childs)

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LAKE S. GILL
1900-1969

Dr. Lake S. Gill died on July 5, 1969 in the Veterans Administration Hospital in Phoenix, Arizona. He is survived by his wife Margaret, his sons John and Ross, a brother Gerald, and five grandchildren.

Lake was born April 25, 1900, in San Francisco, California. Following graduation from secondary schools in California, he attended Virginia Military Institute for 1 year. He enrolled in Stanford University in 1919, where he majored in botany and received a B.A. in 1923 and an M.A. in 1931. Between times, he spent one academic year (1925-26) at the Yale School of Forestry. He returned to Yale in 1932 and received a Ph.D. from the Yale Graduate School in June 1934.

One of the "second generation" forest pathologists in the United States, Lake started out as a field assistant in 1923 under the guidance of Dr. E. P. Meinecke and the watchful eye or Dr. Willis W. Wagener, in the San Francisco office of the Division of Forest Pathology. In 1926, Lake was transferred to the Division's Washington Office. Following this assignment in 1929, he returned to

California, and worked in the San Francisco office until 1932, when he took up the residency at Yale University that led to his doctorate in 1934.

Lake was reassigned to the Albuquerque, New Mexico office of Forest Pathology in 1934, as an understudy to Dr. W. H. Long. Following Long's retirement in 1937, Lake became head of the office and continued in this position until 1954 when he moved to Fort Collins, Colorado, and became Chief of the Division of Forest Disease Research in the Rocky Mountain Forest and Range Experiment Station.

Lake retired from Federal service February 29, 1960, and moved to Apache Junction, Arizona. He spent 1 year in Tanganyika on an FAO assignment, and although he had no other formal appointments, he maintained a lively interest in forest pathology until his death.

Lake is best known for his monographic treatment of the genus Arceuthobium in the United States and his subsequent research and missionary work on the dwarf mistletoes. But his pathological interests were so broadly and solidly based that many of us can look back and recognize it was his knowledge and his interest in our problems that stimulated us to undertake graduate study or new and challenging lines of research. His mild manner and sociability often hid the sharpness of his mind.

He was a member of the Society of American Foresters, Sigma Xi, and the Connecticut Academy of Arts and Sciences. He served in the armed forces in both World War I and II, and reached the rank of major in the latter.

We have lost a charter member of this organization and a great friend. (Stuart R. Andrews)

APPENDIX II. -- ACTIVE PROJECTS

NEW OR MODIFIED*

C. Cone, Seed, and Seedling Diseases

69-C-1 Seed and Cone Diseases of Sequoia sempervirens.

Objective: Elucidation of the sequence of pathological problems affecting seed development, viability, and in survival. Also a study of some of the ecological factors affecting pathogenic deterioration of seed. (John N. Davidson and J. R. Parmeter, Jr.)

D. Root and Soil Diseases and Relationships

69-D-1 Taxonomy of hypogeous mycorrhizal fungi.

Objective: To develop taxonomic order out of the chaos that presently characterizes many taxa of these abundant but little known fungi. (J. M. Trappe)

69-D-2 Stump infection by basidiospores of Poria weirii.

Objective: To determine if stumps can be infected and, if so, under what conditions. (E. E. Nelson)

69-D-3 Relative species susceptibility to Poria weirii infection.

Objective: To compare susceptibility of seedlings of the major western conifers. (E. E. Nelson)

E. Foliage Diseases

69-E-1 Needle lesions of Engelmann spruce.

Objective: To determine the possible causes of lesions by modification of timberline environment. (J. M. Staley)

H. Stem Diseases - Rusts and Cankers

69-H-1 Temperature measurement of white pine tissues: Healthy and infected with Cronartium ribicola Fisch.

Objective: Establish whether there is a measurable temperature difference between visibly active rust

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*For complete list see proceedings of the Fifteenth and Sixteenth Western International Work Conferences, 1967 and 1968.

canker tissue and healthy tissue. If a temperature difference(s) exists, secondary objectives are to measure the magnitude and to determine the effect of time and season on this temperature differential. (R. D. Hungerford)

69-H-2 Thinning and pruning western white pine to control the blister rust disease.

Objective: To determine whether two silvicultural methods, thinning and thinning with pruning, will reduce the risk of loss of white pine crop trees from blister rust and, consequently, whether white pine can be managed to merchantable size or established rotation as a component of mixed stands through use of these cultural practices. (C. D. Leaphart and R. D. Hungerford)

69-H-3 Distribution of blister rust infections in western white pine crowns.

Objective: (1) Establish the pattern of rust intensification in tree crowns over time, as influenced by stand characteristics, especially those induced by silvicultural treatments; (2) evaluate target areas (e.g., stem foliage, short shoots, branch type) as rust hazards, and (3) clarify the influence of favorable infection years (wave years) on intensification patterns. (R. D. Hungerford)

69-H-4 Stimulation of aecia production by *Cronartium ribicola in vivo* in controlled environments.

Objective: (1) Define the duration and magnitude of chilling required for aecia production by rust-infected western white pine seedlings and commensurate with acceptable growth by the seedlings, and (2) to determine if manual cross-fertilization of pycnia is beneficial to aecia production *in vivo* in controlled and modified environments. (E. F. Wicker and A. E. Harvey)

69-H-5 Vegetative propagation procedures for *Cronartium ribicola in vivo*.

Objective: To develop a technology for the artificial inoculation of the pine host (*in vivo*) with mycelium from *Cronartium ribicola*. (A. E. Harvey)

69-H-6 Factors affecting formation of *Cronartium ribicola* aeciospores *in vitro*.

Objective: To investigate and clarify the environmental, nutritional, and sexual factors affecting sporulation of Cronartium ribicola. (A. E. Harvey and J. Y. Woo)

69-H-7 Mode of action of Tuberculina maxima Rostr. in the inactivation of white pine blister rust cankers.

Objective: Determine the mode of action of Tuberculina maxima in the inactivation of white pine blister rust cankers. (E. F. Wicker)

69-H-8 Etiology of comandra rust--dwarf mistletoe infections in lodgepole pine.

Objective: Determine identity and life cycle of a rust fungus associated with dwarf mistletoe in lodgepole pine. (R. G. Krebill)

69-H-9 Cronartium ribicola: effect of suboptimal temperatures on teliospore germination and infection of Pinus albicaulis.

Objective: To determine how low temperatures influence infection of whitebark pine so that we might better evaluate rust hazard in the Rocky Mountains. (R. G. Krebill)

J. Defects and Decays of Forest Products

69-J-1 Basidiomycetes associated with decay of ponderosa pine in the Southwest.

Objective: To establish the identity of Basidiomycetes fruiting on ponderosa pine in the Southwest and to provide an illustrated manual for their identification. (R. L. Gilbertson and A. B. Budington)

## APPENDIX III. -- TERMINATED PROJECTS

66-D-10 Secondary metabolic products of mycorrhizal fungi. (J. M. Trappe and P. Catalfomo)

66-K-9 *In vitro* reaction of *Tuberculina maxima* to cycloheximide and Phytoactin. (D. F. Wicker)

## APPENDIX IV. -- NEW OR MODIFIED TECHNIQUES

### DIFFERENTIATION OF WOOD DECAY FUNGI BY MEANS OF THE INFRARED SPECTRA OF THEIR ETHER EXTRACTS

A. A. Loman

Standard procedures for the identification of cultures of wood decay fungi involve the determination of physiological and morphological characteristics, and of host relationships. The physiological characters include effects on malt agar media containing gallic or tannic acid, color changes induced in malt agar, pigmentation of the mycelial mat, and growth rates. The morphological characters include the formation of fruit bodies, types and septation of hyphae, occurrence of secondary spores, and of cystidia and setae. An excellent key was developed by Nobles[1/] which incorporated several variations of each of the above characteristics.

Recently, attempts were made to identify cultures of wood decay fungi by means of a single characteristic, namely the infrared spectrum of an extract from 10-day-old liquid fungus cultures. Although the infrared spectrophotometer is designed to identify functional groups on a single compound in a purified sample, sharp peaks may be obtained from a mixture, if strongly absorbing functional groups are not repeated on different compounds in such a mixture. The variety of compounds in a mixture may be reduced by a judicious choice of extracting solvents. In order to obtain spectra that may be compared in a meaningful way, it is essential that the substrates of unidentified cultures and reference cultures and reference cultures are identical. The substrates must originate from one stock solution.

Several choices are open to the investigator. One can analyze for changes in substrate components and extracellular metabolites, fungal cell components, or both. This is a summary of the third alternative:

Inoculum was prepared on 10 ml of 2% malt extract agar in 50 mm petri plates. After 10 days of growth on malt agar, the inoculum and substrate were transferred to 500 ml Erlenmeyer flasks containing the following liquid culture: $KH_2PO_4$, 0.5 g; $MgSO_4.7H_2O$, 0.5 g; $NH_4Cl$, 0.5 g; $FeCl_3$ (1% aqueous solution), 10 drops; glucose, 5.0 g; malt extract, 5.0 g; distilled water to 1000 ml. The flasks were swirled a few times by hand three times a day. After 10 days of growth the cultures were acidified with 0.5 ml of concentrated $H_2SO_4$, and homogenized. The homogenate was washed two times with 50 ml of diethyl ether, the aqueous fraction was removed, and the ether fraction was centrifuged at 10,000 rpm for 5 minutes. The ether layer was pipetted off and evaporated to dryness *in vacuo*.

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1/ Nobles, M. K. 1948. Studies in forest pathology. VI. Identification of cultures of wood-rotting fungi. Can. J. Res. C, 26: 281-431.

The residue was dissolved in 5 ml of spectroanalyzed chloroform, transferred to a centrifuge tube and dried with a little anhydrous $MgSO_4$. The solution was dried overnight, centrifuged in a clinical centrifuge at 2000 x g and the clear supernatant was transferred to a clean dry test tube. The supernatant was evaporated to dryness, the residue was dissolved in 3 drops of spectroanalyzed chloroform, and an infrared spectrum was obtained of the solution.

Infrared spectra of different fungal isolates of Armillaria mellea originating from the same host species were identical, but when isolated from different host species, were different. Infrared spectra of different species of Fomes isolated from different host species, and of different genera of fungi, isolated from the same host species, were different.

The reproducibility of infrared spectra of A. mellea isolates from the same hosts, the differences in the infrared spectra of different fungal species of the same genus, and the differences in the spectra of different genera, suggest that this technique may be used for the differentiation and identification of wood decay fungi in culture. For identification purposes, the following conditions are essential: (a) the host substrate of the unidentified fungus must be known, (b) unidentified and reference cultures must originate from the same host substrate, and (c) unidentified and reference cultures must be grown on the same batches of malt extract agar and liquid media under identical environmental conditions, preferably simultaneously.

The differences in infrared spectra of A. mellea isolates from different hosts, indicate that active enzyme systems of a fungal species are adapted to specific host substrates. These differences may be due to adaptive variations in fungal genome within a species, or to selective derepression by specific host substrate components of repressed genes in a common genome.

The results show that infrared spectroscopy is a potentially useful technique for physiological as well as genetic studies of fungi in culture. It also has considerable potential as a tool for the identification of unknown fungal cultures.

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# A SIMPLE, QUANTITATIVE METHOD OF ASSAYING SOIL FOR INHIBITORY FUNGI[1/]

C. Y. Li, K. C. Lu, J. M. Trappe, and W. B. Bollen

Microorganisms isolated from soil can be easily tested for inhibition of root pathogens or other fungi. The isolates are transferred by toothpick probes to the surface of a double-layered agar plate containing mycelium of the subject fungus sandwiched between the agar plate. The subject fungus does not grow under inhibitory organisms. The toothpick probe method permits as much replication as desired.

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1/ Described in detail in Pacific Northwest Forest and Range Experiment Station Research Note PNW-180, 1969.

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## APPENDIX VI. -- BUSINESS MEETING

The following items were discussed:

1. Although invitations were sent by the executive committee to our fellow forest pathologists in Mexico, financial problems prevented any of them from attending the Olympia meeting. It is hoped they may be able to participate in future meetings.

2. The local arrangements committee shall have the authority to arrange banquet program and pay the cost of speakers, etc.

3. An invitation has been received from Mexico to hold the 19th or 20th meeting there. The possibility of holding the 20th meeting in conjunction with the APS meeting in Mexico City was referred to future executive committees.

4. Bob Scharpf was appointed chairman of the mistletoe committee to replace Frank Hawksworth.

5. The 18th meeting will be held at Vancouver, B. C. sometime between August 15 and September 15, 1970.

6. Bob Scharpf was elected Chairman of the 1970 meeting, and Harvey Toko secretary.

7. The following new members were added in 1969:

| | |
|---|---|
| Berntsen, Carl M. | Palmer, John G. |
| Drinkwater, M. H. | Reid, C. P. P. |
| Graham, David A. | Scheffer, T. C. |
| Hildreth, Steven | Shigo, Alex |
| McCain, Arthur H. | Strand, Mary Ann (Mrs.) |
| Mason, Garland N. | Phelps, W. R. |
| Contor, Roger | |

APPENDIX VII. -- COMMITTEE REPORTS

MISTLETOE COMMITTEE

F. G. Hawksworth, Chairman

Highlights of 1969 Activities

I. TAXONOMY, HOSTS, AND DISTRIBUTION

a. A review draft of a taxonomic monograph of the genus Arceuthobium has been completed and circulated to many W.I.F.D.W.C. members for criticism. Publication of the monograph is planned as a U. S. Department of Agriculture Bulletin. (Hawksworth, U.S.F.S., Fort Collins; and Wiens, Univ. of Utah, Salt Lake City)

b. The limber pine dwarf mistletoe, Arceuthobium campylopodum f. cyanocarpum was found in the Bighorn Mountains, Crow Indian Reservation, Montana. This represents an eastward extension of the known range of the mistletoe of about 80 miles. (D. Brown, U.S.F.S., Missoula).

c. The Douglas-fir dwarf mistletoe, Arceuthobium douglasii, usually will not attack pines, but in central Colorado, we know of two instances of parasitism of Pinus flexilis by this species (in the Sangre de Cristo Mountains and on Pikes Peak). (Hawksworth, U.S.F.S., Fort Collins)

d. One of the universal truths in Arceuthobium lore has been that no mistletoe other than A. douglasii will parasitize Pseudotsuga. However, even this standard has now fallen with the discovery by Roger Peterson and Dick Krebill of A. americanum on Douglas-fir near Kamas, Utah. A single Douglas-fir bore several brooms. No shoots were formed, although the endophyte of the mistletoe was present in the brooms. A. americanum was common in associated Pinus ponderosa. A. douglasii does not occur in the immediate vicinity. (Hawksworth, U.S.F.S., Fort Collins)

II. PHYSIOLOGY AND ANATOMY

a. A manuscript has been submitted for publication as a Station Research Paper on "Viability, germination, and radicle growth of Arceuthobium." (Scharpf, U.S.F.S., Berkeley)

b. The eastern dwarf mistletoe, Arceuthobium pusillum Peck., was cultured in vitro on a white's medium supplemented with coconut milk, case in hydrolysate, and growth regulators. Large holdfasts were obtained which arose from a centrally located meristem. Later growth centers were formed near the periphery of the holdfasts. Reticulate thickening of the cell walls was observed in the center area of the holdfasts. Also obtained were

flat structures with branches or papillae. Occasionally centers of meristematic activity developed where radicles and branches were subjected to pressure. (J. M. Bonga, Forestry Research Lab., Fredericton, N. B.)

c. January 1937 was a particularly cold month in California, especially east of the Sierra Nevada Crest. Along the east face of this range, winter injury to trees, mostly pines, was especially noticeable in a narrow belt at about 4,600 feet elevation on the eastern Plumas National Forest southwest of Doyle, California, but gradually rising in elevation to over 8,000 feet toward the southern end of the range. South of Lake Tahoe the belt was marked by the browning of pine foliage but little other injury. However, at the north end, damage within the belt, which varied in width from 25 to 200 yards, depending on the degree of slope, was very severe. Pines of all ages were damaged and up to 75 percent were killed.

On November 12, 1937, nine winter-damaged pines within the belt several miles south of Doyle were tagged for future observation. Two of these had one or more dwarf mistletoe brooms of A. campylopodum in the lower crowns.

| Field notes Nov. 12, 1937 | Reexamination Oct. 27, 1940 |
|---|---|
| PP dbh 20 in., Ht. 80 ft.-- | |
| Most of lower crown killed, also nearly all older needles in upper half of crown. | Upper crown still alive. Lower crown dead except one mistletoe broom at base of former crown. |
| JP dbh 20 in., Ht. 80 ft.-- | |
| About half of foliage killed. Killing heavier in upper crown. In lower crown part of older foliage still alive. | Remaining crown alive; color good. All of lower crown dead except mistletoe brooms. |

These results, although very limited, indicate that pine branches broomed by A. campylopodum are much more resistant to abnormal winter injury than branches unaffected by dwarf mistletoe. I offer no opinion as to why this is so. The information was taken from old field notes. (Willis W. Wagener, PSW, U.S.F.S., Berkeley).

III. LIFE CYCLE STUDIES

a. Studies on the pollination ecology of Arceuthobium americanum were begun in Utah and Colorado. In both areas pollination was principally by insects. Early in the flowering period fungus-gnats and flies were the principal

pollinators, but these were succeeded later in the flowering period by ant pollinators. In both areas, wind dispersal of pollen was very limited. Studies of pollen dispersal by use of radioactive tracers are planned. (Wiens, Univ. of Utah; and Hawksworth, U.S.F., Fort Collins)

b. Dwarf mistletoe seeds were stored at 16 combinations of temperature (-18, 1, 5, and 10° C.) and relative humidity (1, 7, 9, 72 percent). Relative humidities were obtained over drierite and different saturated salt solutions. At 5 months, survival was high (> 90 percent) at low, above-freezing temperature, independent of relative humidity. At 10 months, however, relative humidity seemed more important. Seed stored at 75 percent RH averaged 72 percent germination, while seed stored at all other combinations had less than 20 percent germination. No seed stored at -18° C. survived. (Knutson, U.S.F.S., Corvallis)

c. Investigations of seed dissemination from a single infected western hemlock tree (45 feet tall in 1969) were terminated this year. Estimated amounts of seed dispersed beyond the tree were 7,100, 41,950, 11,275, 20,477, and 28,067 for 1964-68 inclusive. To try to explain the greater dispersal of seed to the south side of the tree than to the north, windspeed and direction were recorded during the time of dispersal for 1967 and 1968. This summer, the tree was dismantled branch by branch to determine the extent and distribution of infections. Preliminary summarization of data indicated that the tree contained 4,377 live infections, some of which were brooms probably developing initially from more than one infection. A high mortality rate of infections was suggested by the 3,001 dead infections, most of which were on otherwise live branches. Nine percent of the live infections bore fruit. Fruit numbered 62,757 on the south side of the tree and 10,795 on the north side. For infections bearing fruit, the average number of fruit produced was 231 on the south and 101 on the north side of the tree. These data, in addition to the wind data, should explain much of the variation in distribution of dispersed seeds experienced in previous years. (R. B. Smith, Forestry Research Lab., Victoria, B.C.)

## IV. HOST-PARASITE RELATIONSHIPS

a. Susceptible and "resistant" candidates of Jeffrey pine at the Institute of Forest Genetics have been patch-grafted with dwarf mistletoe-infected host tissue. Differences in the success and progress of dwarf mistletoe on this host will be investigated. (Scharpf, U.S.F.S.,Berkeley)

b. Dwarf mistletoe-infected and noninfected ponderosa pines in pots will be exposed to filtered air and air containing varying concentrations of ozone in fumigation chambers.

Notes will be taken on the effect of air pollutants on the growth and survival of both the mistletoe-infected and non-infected trees. Also, any effect air pollution has on dwarf mistletoe will be noted. (Scharpf and Miller, U.S.F.S., Berkeley and Riverside)

c. Monterey pines were patch-grafted with dwarf mistletoe-infected host tissue to build up genetically identical clones for further testing. Use of these uniform clones will eliminate any variability in pathogenicity as might occur in the wild types, allow for controlled pollination studies of dwarf mistletoe, and hopefully detect any physiological resistance in Monterey pine. (Scharpf and Kinloch, U.S.F.S., Berkeley)

d. Spread and intensification plots in lodgepole pine and Douglas-fir will be established in the fall of 1969. These will be similar to the Growden plots established by INT on the Colville National Forest. Lodgepole pine plots will be either on the Gallatin or Deerlodge National Forest, and the Douglas-fir plots probably will be on the Lolo National Forest. (Toko, U.S.F.S., Missoula).

V. EFFECTS ON HOSTS

a. Studies on the effects of Arceuthobium americanum on wood properties of lodgepole pine are planned. Comparisons of infected and uninfected wood from the same trees will be made for specific gravity, moisture content, fiber length, fibril angle, modulus of elasticity, toughness, and certain chemicals. (D. Crews, Colo. State Univ., Fort Collins)

b. Specific gravity, moisture content (ovendry basis), and toughness values were determined for infected bole wood of ponderosa pine. Comparisons were made between both sapwood and heartwood (1) immediately above the bole swell, (2) at the infected swell, and (3) right below the swell for trees 3 to 11 inches in diameter. Infected wood had a significantly lower moisture content than noninfected wood. Wood below the swell had the highest moisture content. Specific gravity of wood below the swell was significantly lowest. No difference was detected between values at the swell and above the swell. No differences in toughness were detected. Infected wood did have a peculiar "rubbery" characteristic. Mascerations (in aqueous hydrogen peroxide plus glacial acetic acid) failed to reveal the cause of this abnormality. Tests of dimensional stability plus other strength tests are planned. (Knutson, U.S.F.S., Corvallis)

VI. ECOLOGY

a. We are continuing our previously described studies on ecology and epidemiology of dwarf mistletoe parasitizing ponderosa pine. Collection of damage impact data is being added to some of our experiments originally designed to meet only biological objectives. The first of several publications on this work should soon appear. (Roth, Oregon State Univ.)

VII. CONTROL - CHEMICAL (No reports)

VIII. CONTROL - BIOLOGICAL

a. A review of the literature plus a summary of our observations on insects and mites associated with dwarf mistletoes is being prepared. Life history data for several insects (Neoborella tumida, Callophrys spinetorum plus several Lepidoptera) on A. americanum and A. vaginatum subsp. crypotopodum are being obtained. (Stevens and Hawksworth, U.S.F.S., Fort Collins)

b. A manuscript has been submitted to Phytopathology on "Cytospora abietis associated with dwarf mistletoe on true firs in California." Studies are underway on the physiology of C. abietis to better understand why dwarf mistletoe-infected branches of firs in California are severely attacked by this fungus. Laboratory work is currently underway to determine the factors influencing growth and sporulation of this fungus. (Scharpf, U.S.F.S., Berkeley)

IX. CONTROL - SILVICULTURAL

a. Control in F.Y. 1968 was conducted by six Forests on 3,765 acres by either destruction of residual stands after logging or removal of infected overstory from advanced reproduction. (Toko, U.S.F.S., Missoula)

b. During a 10-year period, dwarf mistletoe infections were pruned yearly from six plots, thinned and sanitized in 1957. Most infections appeared during the first 3 years after sanitation, but latent infections continued to appear over the 10 years. About 45 percent of the initial "uninfected" trees were found to be infected. Latent infections in all trees appear to be related directly to initial stand infection levels. (Shea, U.S.F.S., Corvallis)

c. The 6-class mistletoe rating system will be used to rate dwarf mistletoe-infected trees on Region 3 timber inventory plots. The information collected will be used in estimating growth and mortality losses caused by the dwarf mistletoes. (Weiss, U.S.F.S., Albuquerque)

d. Using the 6-class rating system, Region 6, U.S. Forest Service, is developing a table giving the maximum amount of mistletoe a ponderosa pine tree of a given dbh can have and still qualify as a leave tree. A preliminary table is now being used on a few National Forests in Region 6, and Ken Russell is trying in on State of Washington lands. (J. L. Stewart, U.S.F.S., Portland, and K. W. Russell, Washington Dep. Natural Resources, Olympia)

e. In a joint Region 6-PNW Station study, 6- to 10-year-old plots are being reexamined with the hope of being able to define the rate of intensification of dwarf mistletoe in managed ponderosa pine stands. Results of this study should be available next year. (J. L. Stewart, U.S.F.S., Portland, and K. R. Shea, U.S.F.S., Corvallis)

f. Forest inventory crews are using the 6-class mistletoe rating system to rate each tree on the inventory plots. This will yield additional information on location and intensity of infestation in Oregon and Washington. (J. L. Stewart, U.S.F.S., Portland)

X. SURVEYS

a. The Insect and Disease Survey Section under Alex Molnar has greatly increased efforts to define the distribution of dwarf mistletoe in British Columbia, and to provide data on levels of intensity for various age classes and host combinations. To ensure good coverage, Rangers are plotting their collections on maps provided with a grid system. Collections are made if a prior one has not been recorded within 12 miles. Over 200 new collections were made this summer and were deposited in the herbarium. Intensity is being estimated using prism plots. Trees included in the plots are rated individually using systems differing somewhat, depending on the host. The 6-point system of Hawksworth and Lusher is used for lodgepole pine and Douglas-fir. The rating for larch incorporates a slight modification to cover trunk swellings. For western hemlock, only the bottom two-thirds of the tree are rated, with a maximum of 3 for each third. In this species, stem swellings are given considerable weight. (R. B. Smith, Forestry Research Lab., Victoria, B.C.)

STATEMENT OF PH.D. PROJECT ON MISTLETOES

a. "A simulation of an Arceuthobium campylopodum epidemic on Pinus ponderosa." (M. A. Strand, Oregon State Univ., Corvallis)

SPECIAL NOTE

a. During the summer of 1969, severe and widespread dying of shoots of Arceuthobium americanum, A. campylopodum f.

campylopodum, A. c. f. laricis, and A. douglasii has been observed in northeastern Washington, northern Idaho, and western Montana. I believe this killing to be the result of extremely low temperatures which occurred throughout the area in late December 1968 and January 1969, when minimum temperatures of 50-60° F. below zero were common. (E. F. Wicker, U.S.F.S., Ogden)

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## COMMITTEE ON FOREST DISEASE RECREATION HAZARD

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

### 1969 Program

All Federal agencies with developed recreation sites west of the Mississippi River are now participating in the hazardous Tree Failure Report program. In addition, a number of State agencies and public utilities are providing reports. The increased reporting area has resulted in a more rapid accumulation of data and the development of guidelines for field use.

### 1969 Objectives

As noted in last year's committee report, effective hazard control has been hampered by (1) lack of administrative goals and safety standards, and (2) lack of information and techniques for evaluating hazard. A specific administrative goal is considered essential both for gauging program performance and for operation of a successful hazard control program at minimum cost. With an administrative safety standard based on the defined goal and with a uniform hazard rating procedure, site managers could provide a consistent level of safety throughout an administrative region. Our objective has been to provide both persuasive arguments and the necessary tools for development of goals, safety standards, and improved hazard evaluation programs.

### Progress

Two papers are near completion on "Management of hazard control programs on forested recreation sites." "Administrative goals and safety standards" is addressed to administrative officers responsible for large areas such as an entire State. Establishment of goals and safety standards are illustrated with sample data. Dollar evaluation of the safety standard and cost optimization are explored, and the legal implications of safety standards are discussed.

"Field hazard evaluation and control decisions" is intended for the site manager and hazard inspector. In this we have attempted to develop a logical procedure for consistent evaluation of hazard,

and a rating system compatible with administrative safety standards. With a defined safety standard, the hazard rating system provides a direct control decision for each tree inspected. Potential damage guides (based on Tree Failure Report data) are given for each failure class for the important genera. An illustration of the use of the hazard rating system is also provided.

In the example used in the first paper, one out of every 2½ failures resulted in an accident. It will be to the interest of most administrators to examine their hazard control programs carefully with regard to needed modifications and improvements.

1970 Emphasis

Information is badly needed on the relationship of the class of failure to specific defects and environmental conditions. Study of these relationships will be undertaken in 1970. At the same time, the committee will welcome information or questions on other hazard problems that need attention. (Paine, U.S.F.S., Berkeley)

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## HIGHLIGHTS OF THE FOREST DISEASE CONTROL COMMITTEE

## SECOND ANNUAL REPORT

I. Chemical

Control of the New Needle Pathogen of Hard Pines in Southern Oregon and Northern California

In 1969, five chemicals were tested for their ability to control the new needle pathogen of hard pines found in southern Oregon and northern California. This pathogen, an undescribed species in the family Hypodermataceae, was reported on at the 1968 meeting. Testing is being done on the Umpqua and Willamette National Forests. Chemicals being tested are Difolatan, Zineb, Bordeaux mixture, Daconil 2787, and Manzate. Tests will be read during the fall of 1969. (Bynum)

No other reports received.

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## FOREST DISEASE CONTROL COMMITTEE BUSINESS MEETING

September 26, 1969

1. Larry Weir volunteered to become chairman of this committee for 2 years, effective after the 17th W.I.F.D.W.C. meeting. Members present were Mel Weiss, Frank Yasinski, Tom Laurent,

Al Tegethoff, Don Graham, Jim Stewart, Larry Weir, and Ken Russell. No other business was discussed.

2. A list of disease control personnel in the U. S. and Canada follows: Region 1, Harvey Toko, Oscar Dooling; Region 2, Dwight Hester, Don Brown; Region 3, Frank Yasinski, Mel Weiss; Region 4, Al Tegethoff; Region 5, Dave Graham, Reed Miller, Neil MacGregor; Region 6, Ben Howard, Jim Stewart, Jack Thompson, Hart Bynum; British Columbia, Larry Weir; Washington State, Ken Russell; Alaska, Tom Laurent.

3. This year's report is current for the year only. The first report was retrogressed several years.

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## INTERIM PROGRAM COMMITTEE

James L. Stewart, Chairman

The following list of suggested topics has been forwarded to Al Harvey, the 1970 program chairman:

1. "Pathometrics" - mathematical approaches to pathology.
2. Diagnostic techniques for pathogens.
3. Electronic information retrieval.
4. Panel on research and pest control responsibilities in State and private areas of influence.
5. Workshop on "Teaching Forest Pathology."
6. Diagnosis of decay.
7. A problem-oriented workshop in which disease control prescriptions would be developed for a given stand.
8. Effects of fertilization on disease incidence.
9. Just go out in the woods and discuss various topics.
10. Christmas tree plantation diseases.
11. Dutch elm disease in the West.