

# **PROCEEDINGS OF THE 32<sup>nd</sup> ANNUAL WESTERN INTERNATIONAL FOREST DISEASE WORK CONFERENCE**

**Taos, New Mexico  
September 1984**



# **Proceedings of the 32nd Annual Western International Forest Disease Work Conference**

**Taos, New Mexico  
September 1984**

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## Foreward

Forewards have been part of these proceedings for about 10 years and generally summarize what took place at the meetings. However, a person can usually get this by glancing down the table of contents; hence, no summary here.

Nevertheless, there are some things that should be said here and some that probably should not, but will be said anyhow.

First I want to personally thank Ed Wood for his instillation of a new sense of comradeship among those who participated in his excellent Chao Canyon Tour.

The meetings were of a high calibre, which most people would agree is good; however, it tends to inhibit the hecklers, so when you really need them they are silent. Future WIFDWCs may need to have a planted totally nonsensical paper near the beginning of the program to get the hecklers in shape. In these proceedings you will find a paper by a silent heckler, i.e., a person who did not heckle at the meeting but was in such a state after a presentation that, not only his face was red, but his hair as well. His presentation follows after Bob Brucks', assuming Bob Bruck sends in his paper on time to be included in these proceedings. Constructive heckling should be encouraged and welcomed, particularly by persons presenting papers. In the long run our science should be better and our published journal publications of high calibre (maybe past WIFDWC heckling has resulted in our current high calibre).

Let me continue with a heckling tone; each word in the Proceedings potentially increases the registration

fee. The authors of papers do not need to draw a road map to their place of work or tell us their grandmother's maiden name. All we need is the authors name. All other details can be obtained from the membership list. Secretaries must get estimates on Proceedings costs long before the meeting so local arrangement persons can set costs for registration fees. In order to produce the Proceedings within the estimate costs, printing should proceed directly after the meeting. Hence, why is it so difficult for authors to bring their camera-ready talk to the meeting? They are only punishing themselves and their colleagues. New, completed projects and the publication list could also be sent to the secretary before the meeting. Participants should note the recommended format the secretary has devised to cram as many words on a page as possible.

I also want to thank John Schwandt very much for taking down the business minutes, while I drove through the snow only to find the airplane departure delayed for 2+ h.

### Executive

Tommy Hinds	.....	Chairperson
Rich Hunt	.....	Secretary
Ken Russell	.....	Treasurer
Jim Byler	....	Program chairperson
J. Beatty/E. Wood	...	Local arrangements
Paul Hessburg	.....	Interim chairperson

### Recreation directors

Bob Loomis	.....	Tennis
Terry Shore	.....	Racquet ball
Ed Wood	.....	Inhibition removal

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### Meeting Preambles

- Welcome to Taos by Tommy Hinds and introduction to facilities by Ed Wood.
- Moment of silence for forest service employee Bill Telfer who died in the line of his duty.
- Moment of recognition for WIFDWC charter member Ross Davidson
- Moment of recognition for Frank Hawksworth who received the Barrington Moore Memorial Award for scientific achievement by the Society of American Foresters.
- Keynote address by Tom Schmeckpeper, southwestern deputy regional forester.

My presentation is entitled "A Box of Rotten Apples." Have you ever tried to store apples? After awhile, you always find a few rotten apples in the box, and, if you don't remove these rotten apples, the rot will spread.

My point is that, over the years, we have treated our forests much like that box of apples. Past practices of high-grading our timber stands have created areas that are highly susceptible to insect and disease attack. These "rotten apples," if left untreated, will continue to cause us problems as we try to manage the National Forest in the future.

Before 1920, when the influences of people were slight, insects and diseases played an important part in renewal of the Carson National Forest. Fires cleared the old, decadent forests and made room for

young trees to develop in a cycle of 120 years or more.

After 1920, when we began to harvest trees and effectively prevent and control forest fires, the character of stands on the Carson National Forest changed dramatically in a relatively short time. Because Ponderosa pine was the preferred timber tree, mature, mixed conifer forests were not cut; but where logging was done, the best trees were harvested and less vigorous, undesirable, often diseased trees were left. Concurrently, fire control was highly successful. The inevitable result was the development of dense stands of trees with a higher percentage of shade-tolerant trees like white fir. This condition was favorable to the budworm. (The clean air act curtails the use of fire).

Well, what should we do to solve our most important pest problems? I believe it is obvious that we need to do a better job of obtaining "citizen participation" in our projects. We must be able to define the pest problem and articulate what will most likely take place if none of the solutions available are implemented.

Pathologists have to tackle the difficult task of assessing damage and impact. You must do the basic research and develop methodology to do this work. You have got to invest the time and money to collect the information. You then have to effectively communicate the information to the decisionmaker and the interested public. If you fail to do this important work, we will be leaving the "rotten apples in the box".

Jerry Beatty's three paper panel on simulated yield modelling follows.

MODELING GROWTH AND YIELD OF SOUTHWESTERN MIXED CONIFER  
STANDS INCLUDING EFFECTS OF DWARF MISTLETOE<sup>1</sup>

Carleton B. Edminster and Frank G. Hawksworth<sup>2</sup>

ABSTRACT

Development of a growth and yield model for southwestern mixed conifer stands is described with emphasis on the impact of dwarf mistletoe on growth and mortality of Douglas-fir. Additional studies are needed to quantify the intensification of dwarf mistletoe in mixed species stands, the effects of stand management, and regeneration establishment.

INTRODUCTION

Stand growth and yield models are often characterized by their primary model units and need for information on intertree dependency. Three modeling philosophies are generally recognized (Munro 1974). The first assumes the primary unit is the individual tree, and information concerning intertree distances are required. The second also assumes the primary unit to be modeled is the individual tree, but information on intertree distances is not needed. The third philosophy assumes the stand is the primary unit, and no individual tree information is required.

Stand models which use individual trees as the primary units and are distance dependent can produce very detailed information about the structure and development of the stand. These models depend on some measure of intertree competition based on locations and sizes of trees in the stand. These models are

well adapted to both even- and uneven-aged stands, and are applicable to mixed species and pure stands. Disadvantages of this approach include the requirement for a stem map and excessive computer time to assess intertree competition. These models can be effective research tools, but operational use is limited since stand stem maps are not usually available.

Stand models which use individual trees as the primary units and are distance independent can produce relatively detailed stand information without the use of intertree measurements. Sample tree measurements are more likely to be available on an operational basis for this type of model, and computations of intertree competition indexes are eliminated. Examples of this type of model include the Stand Prognosis Model (Wykoff et al. 1982) and STEMS (USDA Forest Service 1979). These models are also applicable to even- and uneven-aged stands of pure or mixed species, but the development of a specific tree cannot be projected reliably.

Whole stand models use average values such as average tree d.b.h., height, volume, age, and number of stems per unit area to characterize the stand. The conventional normal yield table is an example of such a model. Whole stand models generally do not provide individual tree information and are limited in application to simple age structures (even-aged or two-storied) and stands of a single species unless multiple species demonstrate similar growth characteristics. Use of conventional inventory information and computational efficiency make this type of model operationally attractive. DFSIM (Curtis et al. 1981) and RMYLD (Edminster 1978) are examples of this

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<sup>1</sup>Presented at the Western International Forest Disease Work Conference, Taos, New Mexico, September 24-28, 1984.

<sup>2</sup>Mensurationist and Plant Pathologist, respectively, USDA Forest Service, Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colo.

type of model. While these models provide for flexible management strategies, the limitation to simple stand structures and species composition can be a serious shortcoming.

DIAMETER CLASS MODEL FOR  
SOUTHWESTERN MIXED CONIFERS

As an alternative to the often overly high resolution of individual tree models for operational use and the shortcomings of whole stand models, a model using diameter classes as the primary unit is being constructed for southwestern mixed conifer stands. As with individual tree models, the diameter class model has the capability of projecting the development of stands with any age structure or species composition, but it possesses certain computational efficiencies by grouping trees by similar size classes. Diameter class models provide size distribution information by species or species group. A diameter class model has been developed by Hann (1980) for the ponderosa pine/Arizona fescue type.

The model currently under development is based on data from 237 temporary plots sampled by Dr. Robert L. Mathiasen, formerly of the University of Arizona, in cooperation with Forest Pest Management in Region 3 and the Rocky Mountain Forest and Range Experiment Station. Sampling was concentrated in mixed conifer habitat types on the Kaibab and Apache-Sitgreaves National Forests in Arizona and the Lincoln, Carson, and Santa Fe National Forests in New Mexico.

Eight tree species are separately recognized in the data analysis and modeling (table 1). In addition, two groups of species were formed due to inadequate numbers of observations for single species. Dwarf mistletoes are included in model relationships when a significant effect could be detected. Dwarf mistletoe effects are included in some or all relationships for Douglas-fir, ponderosa pine, Engelmann spruce, and blue spruce. The 6-class dwarf mistletoe rating (DMR) system (Hawksworth 1977) is used to quantify

Table 1.--Trees sampled for development of the southwestern mixed conifer model

Tree species	Number of trees sampled	Percent infected	Dwarf mistletoe
Douglas-fir	20412	37.5	<u>Arceuthobium douglasii</u>
White fir	9840	0.1	<u>A. douglasii</u> <sup>1</sup>
Blue spruce	3639	36.9	<u>A. microcarpum</u>
Aspen	3273	--	-----
Southwestern white pine	2963	0.2	<u>A. apachecum</u> <sup>1</sup>
Engelmann spruce	2897	39.0	<u>A. microcarpum</u>
Ponderosa pine	2305	36.6	<u>A. vaginatum</u> subsp. <u>cryptopodum</u>
Corkbark fir	1839	3.2	<u>A. douglasii</u> <sup>1</sup>
Gambel oak, New Mexico locust, willow	404	--	-----
Pinyon, juniper, bristlecone pine	78	--	-----

<sup>1</sup>Sample of infected trees was too small to model effects of dwarf mistletoe of these hosts.

the intensity of infestation by diameter class. Because of the very small plants of the Douglas-fir dwarf mistletoe and the typically large witches brooms it causes, ratings for this species are based on the proportion of crown volume affected in each third rather than the proportion of branches infected. In the current model, DMR is an integral independent variable in model relationships. It is not used to compute adjustments to noninfested stand performance as in RMYLD.

The current effort at model development is best viewed as a preliminary study with some obvious shortcomings. Due to a lack of long term management in mixed conifer forests, most plots were located in natural stands, some of which may have been partially cut. In most cases it was not possible to detect management strategies to regulate species composition or stocking. As a result, use of model relationships to project managed stand performance should be viewed with caution. For many plots, only site index for Douglas-fir was available (Edminster and Jump 1976). This parameter is used to index site quality in growth relationships for all species. The inadequacies of this approach should be corrected with current site index and habitat type studies in the Southwest. Because most plots represent natural stands, much variability was present in the data. Model relationships were kept as simple as possible unless more complex expressions significantly improved fits to the data. As wide a range of stand conditions were sampled as possible, including species composition, age structure, and severity of dwarf mistletoe infestation. Site index for Douglas-fir ranged from 47 to 108 feet at b.h. age 100 years, with an average slightly over 75 feet. Stand basal area ranged from approximately 60 to 380 square feet per acre with an average of 185 square feet. Relationships for the major species, Douglas-fir, will be discussed in some detail with emphasis on the effects of dwarf mistletoe as examples of periodic stand development relationships.

## Diameter Growth

In a diameter class model, the diameter growth expression is the driving relationship. The equation to predict future diameter of a class average diameter included the following independent variables or expressions: average class diameter at the beginning of a 10-year period, total stand basal area, site index, average dwarf mistletoe rating, the ratio of basal area above the subject diameter class to total basal area as an index to the position of the diameter class in the stand basal area distribution, and the square of the natural logarithm of the class diameter to account for curvilinearity in the data. For most species coefficients of determination ( $R^2$ ) were nearly one as expected for the estimation of future diameter from past, but standard errors of estimate were fairly large (0.2 to 0.3 inches) indicating a large amount of unexplained variability.

Estimated effects of class diameter, stand density and DMR on 10-year periodic diameter growth are presented in figure 1 and table 2 for an average site index of 75 feet. Diameter increments for the 15- and 20-inch classes are nearly equal and are shown by a single line in figure 1. The increased effect of dwarf mistletoe on smaller trees and at higher basal areas is evident in percentage terms (table 2).

## Height and Volume Estimation

Class height is estimated from diameter using a generalization of the Richards' growth function (Richards 1959) which has a sigmoidal shape. The upper asymptote of the function is based on an expression of site index, and the shape of the curve is slightly modified by a stand basal area term. The stand density term has the effect of predicting somewhat greater heights for trees in a given diameter class in dense stands compared to those in more open stands. This is an attempt to make the height model less sensitive to stand

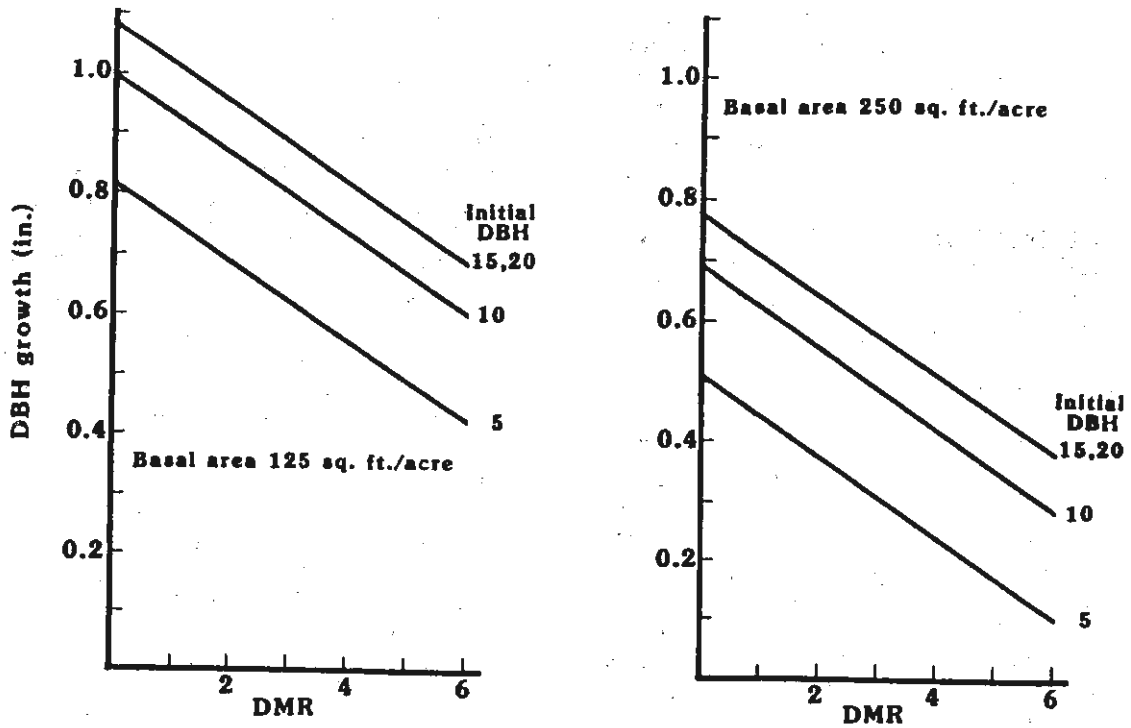


Figure 1.--Estimated 10-year periodic diameter growth of Douglas-fir trees in southwestern mixed conifer stands at site index 75 in relation to dwarf mistletoe rating.

Table 2.--Estimated 10-year periodic diameter growth (inches) of Douglas-fir trees in southwestern mixed conifer stands at site index 75 in relation to dwarf mistletoe rating, initial d.b.h. (inches), and stand density.

Initial d.b.h.	Dwarf mistletoe rating						
	0	1	2	3	4	5	6
Basal area 125 square feet per acre							
5	0.82	0.75(8) <sup>1</sup>	0.69(16)	0.62(24)	0.55(33)	0.49(41)	0.42(49)
10	1.00	.93(7)	.87(13)	.80(20)	.73(27)	.67(33)	.60(40)
15	1.08	1.01(6)	.94(12)	.88(19)	.81(25)	.74(31)	.68(37)
20	1.09	1.02(6)	.96(12)	.89(18)	.82(24)	.76(31)	.69(37)
Basal area 250 square feet per acre							
5	0.51	0.44(13)	0.37(26)	0.31(40)	0.24(53)	0.17(66)	0.11(79)
10	.69	.62(10)	.55(19)	.49(29)	.42(39)	.35(49)	.29(58)
15	.76	.70(9)	.63(18)	.56(26)	.50(35)	.43(44)	.36(52)
20	.78	.71(9)	.64(17)	.58(26)	.51(34)	.44(43)	.38(52)

<sup>1</sup>Percent reduction in growth of infected trees is given in parentheses.

density than the diameter growth model. For most species the  $R^2$ 's for the height equation ranged from 0.90 to 0.95 and the standard errors of estimate were from 5 to 10 feet.

Class volumes are then computed from standard Regional volume equations (Hann

and Bare 1978) using class average diameters and heights. Figure 2 and table 3 present 10-year periodic average tree growth within a diameter class for total cubic volume using the Carson-Santa Fe equations. Stand conditions are the same as for figure 1 and table 2. Again the increased effect

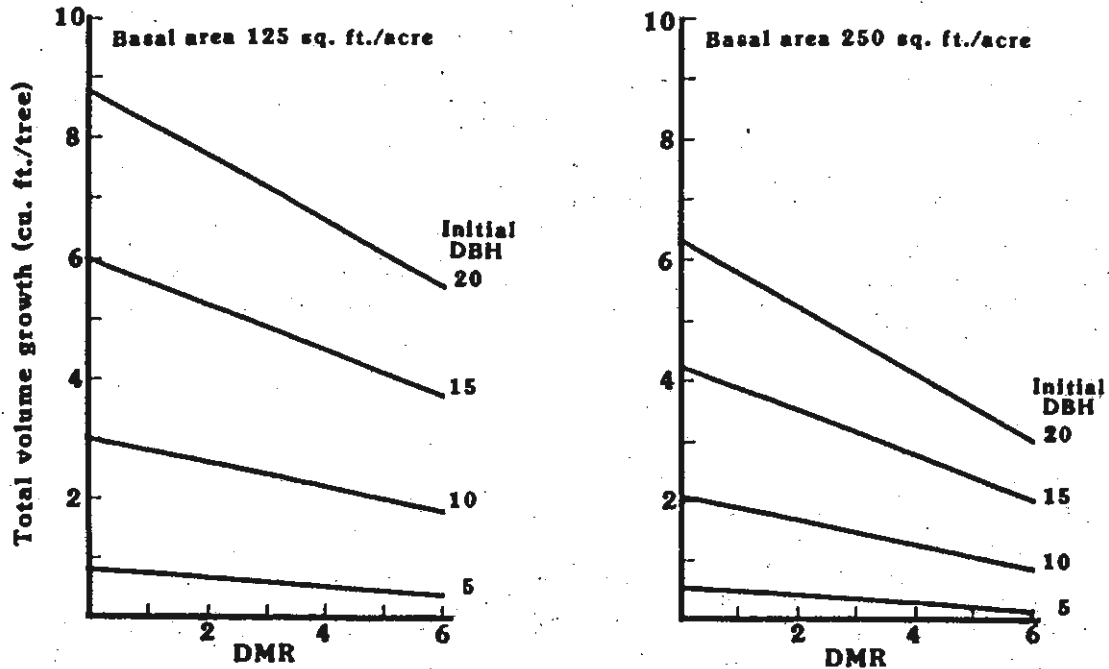


Figure 2.--Estimated 10-year periodic total stem wood volume growth of Douglas-fir trees in southwestern mixed conifer stands at site index 75 in relation to dwarf mistletoe rating.

Table 3.--Estimated 10-year periodic total stem wood volume growth (cubic feet per tree) of Douglas-fir trees in southwestern mixed conifer stands at site index 75 in relation to dwarf mistletoe rating, initial d.b.h. (inches), and stand density.

Initial d.b.h. inches	Dwarf mistletoe rating						
	0	1	2	3	4	5	6
Basal area 125 square feet per acre							
5	0.79	0.72(9) <sup>1</sup>	0.65(18)	0.58(27)	0.51(36)	0.44(44)	0.38(52)
10	3.05	2.83(7)	2.62(14)	2.40(21)	2.19(28)	1.98(35)	1.77(42)
15	5.98	5.59(6)	5.20(13)	4.82(19)	4.44(26)	4.06(32)	3.68(38)
20	8.85	8.23(6)	7.74(13)	7.18(19)	6.63(25)	6.08(31)	5.53(38)
Basal area 250 square feet per acre							
5	0.48	0.41(14)	0.35(28)	0.28(42)	0.22(55)	0.15(68)	0.09(81)
10	2.08	1.87(10)	1.66(20)	1.45(30)	1.25(40)	1.04(50)	.84(60)
15	4.21	3.83(9)	3.45(18)	3.08(27)	2.70(36)	2.33(45)	1.96(53)
20	6.26	5.71(9)	5.16(18)	4.62(26)	4.07(35)	3.53(44)	2.99(52)

<sup>1</sup>Percent reduction in growth of infected trees is given in parentheses.

of dwarf mistletoe on smaller trees and at higher stand densities is evident (table 3).

#### Mortality

Development of reliable relationships for periodic mortality is usually one of the most difficult tasks in the

construction of growth and yield models. The current study has proved to be no exception, especially with the great variability inherent in natural stands. To arrive at a meaningful relationship for the proportion of mortality to stand characteristics, observations which represented more than 20 trees on a plot basis were grouped into 5-inch wide

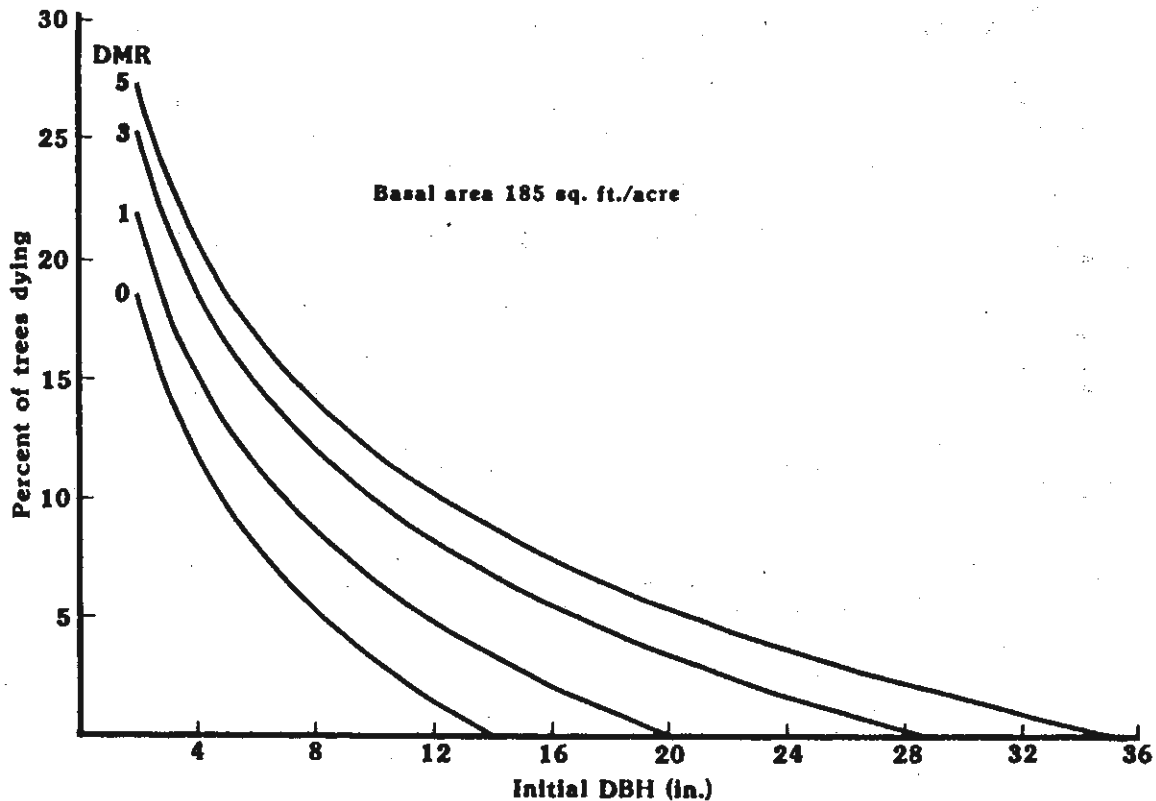


Figure 3.--Estimated 10-year periodic mortality of Douglas-fir in southwestern mixed conifer stands in relation to initial d.b.h. and dwarf mistletoe rating.

diameter classes, basal area classes 50 square feet per acre wide, and 5 DMR classes. An equation was developed by stepwise regression using the natural logarithms of class average diameter, total stand basal area, and DMR as independent variables to estimate the proportion of trees dying in a given diameter class during a 10-year period. This model performed better than logistic and other nonlinear models. Site index did not have a significant relationship to mortality for any of the species. Even with grouping the data, coefficients of determination were generally poor, ranging from 0.2 to 0.7. A plot of the 10-year periodic mortality relationships for Douglas-fir at an average stand basal area of 185 square feet per acre is shown in figure 3. As an example of the estimated impact of dwarf mistletoe, the following 10-year periodic mortality is expected for 8-inch diameter trees:

DMR	Percent of trees dying
0	5.3
1	8.7
3	12.1
5	14.1

#### Regeneration

Regeneration will be a user supplied variable in the first version of the model, as it was not possible to develop meaningful relationships on the establishment of seedlings by species and habitat types. Weak relationships are available to predict survival of seedlings and ingrowth into the lowest diameter class (trees over 4.5 feet) for most species based on stand basal area.

#### Intensification of Dwarf Mistletoe

Direct information on intensification of dwarf mistletoes is not available due to the sampling of temporary plots without aging infections. It is possible to

model general trends with ages of diameter classes, and these relative trends will be used in the preliminary model. The accuracy of these trends will very likely be poor when applied to managed stands where dwarf mistletoe control is practiced. As information becomes available it may be possible to model the infested and noninfested portions of the stand separately, but the current modeling effort estimates the average development of infested and noninfested trees within diameter classes. Predicting intensification of dwarf mistletoes is a complex problem considering changes which occur in species composition and stand structure both naturally and under management.

#### RESEARCH NEEDS

The modeling effort has uncovered some critical gaps in knowledge which should receive priority in research planning. The first gap is the intensification of dwarf mistletoes in stands of varying species composition and stand structure. This problem becomes more critical as a wide range of silvicultural treatments are applied to mixed conifer stands. This leads to the second gap which is the effect of stand management on growth and yield of these stands. The third major area is the prediction of regeneration establishment under current forest conditions and future management. Long term permanent plots can be useful in filling all of these gaps, but a commitment is necessary for their establishment and maintenance. In the meantime short term studies are possible in at least the first and third areas to provide more timely answers.

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THE MODELING OF DWARF MISTLETOE  
EFFECT AND THE PROGNOSIS GROWTH  
AND YIELD SYSTEM

Michael A. Marsden

In March of 1983 there was a workshop on modeling the effects of dwarf mistletoe. The major species of host trees were Douglas-fir, lodgepole pine, and western larch. At this meeting Regions 1, 2, 4, and 6 were represented, as well as TM-WO, INT, RM, and CSU.

One of the products of this meeting was a schedule of work. According to it we are almost a year behind. This will happen when you develop a schedule at a meeting, but you directly control neither the funds nor the people. We have, however, worked cooperatively the last two years, each at his own pace. A model for the spread, intensification, and growth impact of dwarf mistletoe on lodgepole pine has been developed. It is now of an untested subroutine for the variant of the Prognosis stand growth model being developed for southeastern Oregon.

The dwarf mistletoe model is based on data from both eastern Oregon and eastern Montana. The stands sampled are dominantly lodgepole pine. Those in eastern Montana were remeasured this past summer, giving us a set of data to test the model.

The INT has collected data on Douglas-fir and dwarf mistletoe, but they do not have spread and intensification data.

The inventory data from the Boise and Targee National Forests will have dwarf mistletoe effects in them. There are thinning studies in Region 4 which include the dwarf mistletoe on lodgepole pine which we can use to either test or calibrate the model.

The development of a dwarf mistletoe model for use with the Prognosis growth and yield model has been done chiefly by Ralph Johnson and Oscar Dooling of Region 1; Tommy Gregg, Region 4; and myself. The enhancement of this model to produce models for other species and other areas will involve many others.

Timber growth and yield models have been around for some time now and are used to develop stand prescriptions and forest plans; the use of pest models with growth and yield models is a more recent development. There are several insect models developed for use with the Prognosis systems and, in the near future, there will probably be an equal number of disease models. Figure 1 identifies some of the variants of Prognosis and the pest submodels.

Figure 1: Special Submodels for Use With Prognosis

Special Subroutine or Submodel  
X - Already linked; 0 - Will be linked

Prognosis Variant	P-model	MPB	DFTM	WSBW	Cover	Reg.	DM	Cheapo*
Inland Empire (40)	4.2		X		X			X
East Montana (MTs)	4.2	X			X			X
Region 6 (640)	4.2		X		X			X
Hexperce NF (R24)	4.2				X			X
Teton NF (TT)	4.0	X			X			X
Utah (UT)	4.0	X			X			X
Univ. Idaho (IWD)	4.0		X		X			X
Region 6 (64R)	4.1		X		X			X
Region 6 (R6B)	4.2	X						X
Prognosis 5 (50)	5.0		0	0	0	0	0	0
South-East OR (SEO)	5.0	0	0	0	0	0	0	0

- \* MPB = Mountain pine beetle
- DFTM = Douglas-fir tussock moth
- WSBW = Western spruce budworm
- Cover = Understory vegetation model N.I
- Reg. = Regeneration model N.I.
- DM = Dwarf mistletoe model
- Cheapo = Economic model

## FIDMREC - A FOREST PEST MANAGEMENT TOOL

JAMES S. HADFIELD

FIDMREC is an acronym for Forest Insect and Disease Management Recommendations. FIDMREC is a computer program that lists management recommendations for insects and diseases of several Pacific Northwest tree species. The present version of FIDMREC covers 12 tree species. It has recommendations for 28 pests, 18 diseases, and 10 insects. It can list recommendations for 344 types of forest stands.

Our purpose for developing FIDMREC is to provide foresters rapid access to insect and disease management recommendations specific to their stand conditions so they can incorporate the information into their forest prescriptions. The intent is to have FIDMREC supplement, not replace, pathologists and entomologists.

Although FIDMREC is a new tool for managing forest pests, the concept is not new. A similar program called Integrated Pest Management-Decision Key has been available for 3 years in the southeastern United States. Similar programs have been available for agronomic crops and human diseases for several years.

FIDMREC is built around the realization that a relatively small number of pests cause the bulk of the damage in our area. The occurrence of these pests is influenced by stand conditions, including geographic location, and we spend a lot of time offering the same recommendations for similar situations.

The computer is an excellent tool for storing and retrieving large quantities of information. It is particularly well suited for handling many repetitive tasks such as responding to the same question time after time. An example is the computer connected to the automatic teller at the bank that asks you to enter the amount of money you wish to withdraw or "do you want another transaction?" or, in our case, "is dwarf mistletoe present?"

FIDMREC uses a decision tree design. Each tree species is a separate decision tree so to speak. A series of questions serve to elicit user responses that describe the use and characteristics of the stand of interest. If occurrence of a specific pest is influenced by location of the tree species within the region, the first question will identify the location of the stand. An example is: Douglas-fir dwarf mistletoe does not occur on Douglas-fir in western Washington or northwestern Oregon and Douglas-fir tussock moth does not occur in western Oregon or Washington so the program sets up three Douglas-fir zones in the region. Another question for all tree species establishes the broad use as being either timber production or developed recreation; that is, campgrounds or picnic areas. Dispersed recreation areas are treated as timber production sites. This was done because the cost of treatments is usually much greater within the developed sites because we are looking at individual tree treatments. All questions are phrased so as to be answered with a yes or no response. In designing the program, all yes responses go to the left, all no responses go to the right. Other questions asked are "is the stand at or beyond normal rotation?" "Is the average stand DBH small enough for precommercial thinning?" "Is dwarf mistletoe present?" "Are beetles killing trees?" The largest number of questions ever asked is nine.

The program does not require the user to identify precisely a pest to species; instead it deals in generic terms such as beetles, dwarf mistletoe, root rots, and defoliators. FIDMREC identifies the pest or pests on the basis of stand characteristics. The present version of FIDMREC requires no numerical data input. Planned modifications will allow for this.

Pathologists and entomologists developed a set of recommendations for each pest. At the present time, FIDMREC contains a list of 100 recommendations. Each pest was assigned a block of identifying recommendation numbers with plenty of room for expansion. Recommendations were then selected for each ending point on the decision trees. In several cases, more than one recommendation for a specific pest was included because there can be more than one method of managing a pest.

Recommendations appear in two forms. The short recommendations are generally only one sentence. The detailed recommendations are expanded versions that provide more information.

After the user has entered enough information to characterize the stand, the program will produce a set of short recommendations, each preceded by an identifier number. After all the short recommendations for the stand have been displayed, the program asks the user if more information on the recommendations is desired. If the answer is yes, the user can select any or all of the recommendations. If no more information is needed for a particular stand, the program will ask the user if they want to start over at tree species selection or terminate the session.

FIDMREC is written in FORTRAN. The program is long, but not complicated. It is on the USDA computer at the Fort Collins Computer Center and can be run by anyone with access to this facility. To run FIDMREC, use the run statement:

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@XQT R6FPM*IPM.FIDMREC
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FIDMREC has many advantages over other systems of delivering insect and disease management advice.

It is almost infinitely expandable. We could include every tree species and pest problem in the Pacific Northwest or even the entire country. We will be expanding it to include commonly encountered mixed-species stands. We will be adding some other uses such as forest nurseries and seed orchards.

FIDMREC is cheap. Compared to the cost of preparing full-color publications, preparation costs for FIDMREC were very inexpensive. Operating costs are very reasonable.

The program is very easy to modify and update, unlike publications. We have made numerous changes in the program and will be making many more.

The program is widely available. Any office with a computer can use FIDMREC.

Site-specific information is provided very quickly.

There is less hassle gaining approval compared to a publication, especially a publication with color photos.

FIDMREC has an option that allows us to monitor who is using the program. If we see numerous inquiries, we can contact the users to suggest on-the-ground visits by pathologists and entomologists. Several changes and additions are planned for FIDMREC. We will be adding commonly-encountered tree species mixes to the tree selection menu. Help statements will be added for users who do not understand the stand characterization questions. Quantifiable data will be input through multiple choice ranges. Literature citations will be added to the detailed recommendations. Other R-6 FPM programs such as FIROT, ET, LPDMVOL, and WPBR status will be hooked into FIDMREC. Stands will be characterized to a more precise level to reduce the number of recommendations for a given stand.

We are pleased with the way FIDMREC is operating. It is another tool pest managers can use for dissemination of pest management information to forest managers.

IS A PATHOGEN THE PRIMARY CAUSE OF DECLINE  
AND MORTALITY OF CHAMAECYPARIS  
NOOTKATENSIS IN SOUTHEAST ALASKA?

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Introduction

Alaska-cedar (Chamaecyparis  
nootkatensis (D. Don) Spach) is a long-  
lived, slow-growing conifer ranging from  
near the Oregon-California border, through  
British Columbia, to Prince William Sound  
in Alaska (3). It has extreme decay  
resistance, tight grain, and a bright  
yellow heartwood. Extensive mortality has  
occurred for many years in stands of C.  
nootkatensis throughout southeast Alaska  
(6). Early reports associated mortality  
with bog and semi-bog sites (5).  
Mortality was speculatively attributed to  
Phloeosinus bark beetles (2,5), Armillaria  
sp. or other root pathogens (7), or winter  
desiccation (1). Our work represents the  
first systematic investigation of this  
cedar problem.

In 1981 we initiated investigations  
on decline of Alaska-cedar with Tom  
Laurent and Andy Eglitis (Entomologist) of  
Forest Pest Management, State and Private  
Forestry, Juneau. Our efforts were  
directed at describing symptoms of dying  
cedars, isolating pathogenic fungi, and  
determining the role of bark beetles. We  
began more detailed studies in 1982  
through a cooperative project with the  
Forestry Sciences Lab in Juneau and the  
Department of Botany and Plant Pathology  
at Oregon State University. Our primary  
objective was to determine the cause of  
Alaska-cedar decline. More specifically,  
we have attempted to test the hypothesis  
that decline and mortality of Alaska-cedar  
is caused by a pathogenic agent.

Symptoms of Decline

Crowns of affected cedars decline and  
die as a unit rather than as flagging of  
isolated branches. Some cedars appear to  
die quickly; others decline over many  
years. Fast-dying cedars generally have a  
full compliment of foliage, but the entire  
crown changes in color from green to  
yellow or gold, then bronze, before

turning brown. These cedars are often,  
but not always, attacked by Armillaria or  
bark beetles, or both. In contrast to the  
above symptoms, most trees die slowly,  
with foliage gradually changing color and  
thinning. Crowns of severely declining  
cedars appear thin and have remaining  
green foliage only on the branch tips.  
These cedars have slowed in radial growth  
during the 5 to 10 or more years prior to  
death.

The root systems of 40 healthy and  
declining cedars were excavated to collect  
material for fungal isolations and to  
examine the development of root symptoms  
in cedars showing an array of crown  
symptoms. The objective of this procedure  
was to determine the sequence of  
development of root and crown symptoms as  
cedars progress through stages of decline.

Dead or missing fine roots (<2mm)  
were observed on cedars with early crown  
symptoms (i.e., thin or off color, or  
both). Dead small roots (approx. 1 cm  
diam.), along with more dead and missing  
fine roots, occurred on cedars having  
crowns with a greater proportion of  
missing or off-color foliage. In cedars  
with extensive crown decline, more and  
larger diameter roots were dead--likely  
from spread of cambial lesions present on  
smaller, distal roots. These lesions  
eventually spread to the root collar and  
up the bole in long vertical (non-  
girdling) streaks of dead phloem above one  
or more dead roots. The cambium in  
branches and high portions of the bole was  
often the last tissue to die. These  
symptoms suggest that a root pathogen  
causes decline.

Fungi on Healthy, Declining, and Dead  
Cedar

Fungi isolated (Table 1) or collected  
(Table 2) from healthy, dying, or dead  
Alaska-cedars were identified and tested  
to evaluate their roles as primary or  
secondary contributors to cedar decline.  
A total of 47 fungi were identified to  
genus or species; 31 of these are new  
reports on Alaska-cedar. Gymnosporangium  
nootkatense and Armillaria sp.), two known  
pathogens, were obtained from Alaska-  
cedars, however their occurrence on dying  
cedars was too infrequent to consider

either as a primary cause of decline.

The most commonly isolated fungi included: Mycelium radialis atrovirens (235) times, primarily from fine roots), Cryptosporiopsis sp. (89 times, consistently from margins of root lesions), Cylindrocarpon didymum (70 times, from fine roots and margins of stem lesions), and Gelatinosporium (=Dermea) sp. (79 times, from stem lesions, bark, and branches).

The ten fungi most commonly isolated from symptomatic tissues were tested for pathogenicity by inoculations (spring and fall) onto the root collar of Alaska-cedar seedlings. Cylindrocarpon didymum was the only fungus to show pathogenicity. It consistently caused lesions (e.g., 3-5 cm long); however these lesions eventually callused and seedlings were not killed.

A concentrated effort was made to isolate fungi from stem lesions arising from dead roots since this was a common symptom on dying cedars. Samples were taken in advance of the lesion, at the lesion margin, and at several locations behind the advancing margin. Lesion margins were often sterile (53%), but fungi were more common further down the lesion (Fig. 1). Several fungi (Cryptosporiopsis and Cylindrocarpon) occurred primarily near the lesion top, while others were more frequent further down--suggesting a succession of fungi in advancing lesions. Cryptosporiopsis was the most commonly isolated fungus from the margins of root lesions.

To determine if lesions could be induced on healthy cedars, square pieces (4 x 4 cm) of bark and phloem were cut from just below the margin of lesions and placed into the root collar of healthy cedars. Lesions failed to develop in inoculated cedars after 2 years, or lesions were very short and callusing. These isolation and inoculation results suggest that a pathogen is not primarily responsible for lesion advance.

#### Organisms Associated with Fine Roots

Fine roots of healthy or dying cedars were microscopically examined to determine if vesicular-arbuscular (VA) mycorrhizae

were absent, and, thereby, contributing to the decline syndrome. Generally, VA mycorrhizae occurred in all fine roots that were living, regardless of the stage of cedar decline.

Mycelium radialis atrovirens, commonly considered to be mycorrhizal, was isolated several hundred times from fine roots of healthy or dying cedars. This fungus was microscopically observed inside root cortical cells of nearly all live fine roots examined. Stem inoculations failed to show pathogenicity. Inoculations of fine root are now in progress.

An Aphelenchoides sp., was isolated along with fungi from fine roots of dying cedars. This nematode possesses a stylet and is potentially plant pathogenic. Consequently, nematode sampling was conducted from the fine roots and soil of 31 dying or healthy cedars. Large populations of Aphelenchoides or other nematodes were not found.

Recently, a Phytophthora sp. was isolated from the organic matter beneath Alaska cedars.<sup>1/</sup> Thus far, Phytophthora has been isolated from beneath only four of approximately 100 trees sampled. It has not been directly isolated from fine roots, lesions, or any other tissues of Alaska cedar. At present we are unable to comment on its possible role in cedar decline. Necessary pathogenicity tests, more sampling to determine abundance and geographic distribution, and work on the taxonomic status of these Phytophthora isolates are in progress.

In summary, although symptoms of dying cedars suggest pathogen involvement, no likely primary pathogen has been found.

#### Basal Scars

Triangular, callusing scars at the tree base were common on cedars. The incidence and cause of this scarring were investigated to determine if scars were

<sup>1/</sup> Phil B. Hamm is gratefully acknowledged.

important symptoms in decline of Alaska-cedar. In our primary study area, most of these scars were caused by springtime activities of Alaska brown bears (Ursus arctos). Fresh scars consistently had teeth or bite marks and often occurred in groups of 5 or 10 cedars. More than one half of the cedars present in many stands had one or more scars, which probably will result in significant cull in the valuable butt logs. Basal scars were also common in highly productive stands without decline; conversely, cedar decline was severe and scars were scarce on several islands not inhabited by brown bears. Therefore, basal scars, even though common and damaging at some locations, are not a factor in cedar decline.

#### Epidemiology of Mortality

The epidemiology of decline was explored to help distinguish between environmental factors and (hypothetical) primary pathogens as causal agents of cedar decline.

The onset of mortality was dated by analyzing the earliest available aerial photographs for cedar mortality and by determining the year of death for individual cedar snags. Aerial photographs of our study area taken in 1927 were acquired; widespread cedar mortality is evident on these 1927 photographs at all sites that presently have dying cedars.

Time of death for individual cedar snags was calculated by either: 1) determining from growth rings the year of release of previously suppressed trees growing under larger cedar snags; or 2) by aging callus rings on particular cedars with dead tops and dead boles except a narrow, vertical callus strip connecting to a single live branch cluster. These cedars were used to estimate years since death of completely dead snags with tops in a similar stage of deterioration.

Cedar snags were placed into one of five snag classes based on the degree of foliage, twig, and branch retention. Approximate time since death of the five snag classes, based on the two above methods, are listed below:

Snag Class	Characteristics	Average # Years Since Death	Standard Deviation
1	foliage retained	3	3
2	twigs retained	11	7
3	secondary branches retained	31	14
4	primary branches retained	54	23
5	no branches retained	81	22

These data suggest that mortality began before the turn of the century. A sixth snag class, with broken and deteriorating boles, was infrequently encountered, often outside of mortality sites, and probably predates the onset of extensive mortality. Cedars in each of the five snag classes occurred commonly in mortality areas--indicating that cedar mortality was not a one-time event of the past, but continues today.

#### Spread of Mortality

The boundaries of areas with cedar mortality were mapped for 7 locations on aerial photographs taken in 1927, 1948, 1965, and 1976. Figure 2 is an example of the sequential maps of one site. Mortality has spread at all 7 locations since 1927. The edge of the area expressing mortality appears to have spread outward with a scattering of cedars dying ahead of others, rather than a narrow, advancing band of dying cedars. At some locations (e.g., Fig. 2), a "green zone" now appears where mortality was severe in 1927. This green zone is usually comprised of hemlocks (Tsuga heterophylla and T. mertensiana) and released cedars that were not killed in the original mortality. Recurring mortality has prevented green zones on other sites where long-dead and recently killed snags occur together.

## Plant Community Relationships

Understory plant communities were analyzed in an attempt to better interpret patterns of mortality spread. The dominance of 55 understory plant taxa was recorded, along with conifer basal area and cedar snag types, on 280 plots along transects extending through cedar mortality. A computer ordination technique, DECORANA, was used to determine and evaluate gradients of understory plant distribution. Ordination scores for both plots and plant taxa were produced from the first and only important axis generated. This axis represented the gradient from wet, open bogs to better drained sites.

Alaska-cedar was the dominant component (Fig. 3) across much of the gradient from bog to better drained site. Except for mountain hemlock, other conifers were more confined to one or the other end of this gradient.

The pattern of spreading mortality becomes evident by analyzing the relationship of cedar snag classes to this bog to better drained gradient (Fig. 4). Long-dead snags (i.e., no limbs retained) tend to occur on sites with bog understory plants, whereas the most recently killed snags (dead foliage retained) occur on sites with understory plants indicating better drainage. Spreading mortality is most evident on sites with a gradual gradient from bog to better drainage. The spreading mortality does not occur where a transition from bog to a well drained site is abrupt. Vast, continuous cedar mortality occurs without spreading patterns on large areas of a mosaic of bog and semi-bog types. The cedar decline problem has not been observed where cedar grows with a high proportion of western hemlock and spruce on the best drained and most productive sites.

## Conclusions

Symptoms of dying Alaska-cedar seem typical of many forest tree declines (4): reduced radial growth, early root degeneration, yellowing of foliage, and the frequent presence of *Armillaria* sp. These symptoms, along with spreading mortality patterns and the host-specificity of the

decline would suggest pathogen involvement. Thus far, however, no organism has been consistently found or isolated that is capable of the widespread and long-term destruction that has occurred. Several secondary organisms, including fungi, nematodes, and bark beetles, have been found, but none seems capable of killing an unstressed cedar.

Cedar mortality is a fairly consistent feature of bog and semi-bog sites throughout the many islands and mainland of southeast Alaska. Cedar decline appeared nearly simultaneously in widely separate and often remote regions of southeast Alaska before the turn of the century. If a primary pathogen was involved, a strong case could be made for its being endemic to the bogs of southeast Alaska. Abiotic factors would likely have triggered such a relatively sudden and widespread emergence of a pathogen.

The development of patterns of spreading mortality has followed an ecological gradient from bog to better drained site. All stands that we have examined with currently dying cedars also have old class 5 snags nearby. Also, mortality is evident on 1927 aerial photographs from all areas where cedars are currently dying. Together, these observations strongly suggest that no new locations of mortality have developed since the onset of the problem. These results contradict the argument that an infectious-pathogen is the primary cause and support the view that abiotic factors are primarily responsible for decline of Alaska-cedar.

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TABLE 1. Fungi isolated from Alaska cedar in southeast Alaska.

Species	No. of Isolates	Fine Roots	Coarse Roots	Root Collar	Origin					
					Stem Lesion	Living Phloem	Bear Scar	Sap Stain	Branches	
<b>ASCOMYCELES</b>										
a <u>Ceratocystis (=Chalara)</u>	5							+		
ab <u>Derma (=Gelatinosporium)</u>	79				+		+			+
a <u>Gromoniella sp.</u>	2	+								
<b>BASIDIOMYCETES</b>										
a <u>Ditangium sp.</u>	1									+
Unidentified sp. 1	29	+		+	+					+
Unidentified sp. 2	31	+	+	+	+	+			+	+
a <u>Polyporus elegans</u>	8				+					+
<b>IMPERFECTS</b>										
a <u>Cryptosporiopsis sp.</u>	89	+	+		+					
a <u>Phialophora melinii</u>	50		+	+	+				+	+
a <u>Cylindrocarpon didymum</u>	70	+	+		+					
a <u>Dictyosporium elegans</u>	2				+					+
a <u>Spegazzinia tricholophila</u>	11	+	+	+					+	
a <u>Sporidesmium sp.</u>	75	+	+	+	+				+	+
a <u>Septonema secedens</u>	1				+					
a <u>Phoma sp.</u>			+							
ab <u>Seiridium cardinale</u>	1									+
Graphium sp. 1	36		+	+					+	+
Graphium sp. 2	4						+		+	+
a <u>Gliocladium</u>	1	+								
<u>Verticillium</u>	1				+					
<b>MYCELIA STERILIA</b>										
a <u>Mycelium radicle atrovirens</u>	235	+	+	+	+	+				+

a = First report from Alaska cedar.

b = Identification or verification by A. Funk gratefully acknowledged.

TABLE 2. Fungi fruiting on Alaska cedar in southeast Alaska.

Species	Origin								
	Stem Lesion	Bear Scar	Live Bark	Recent Snag	Old Snag	Down Log	Twigs	Foliage	Seedling
ASCOMYCETES									
								+	+
a						+			
		+				+	+	+	
ab	+		+						
a			+						
a				+					
				+					
s		+							
a				+		+			
a					+				
a			+						
a	+	+	+	+	+	+	+		
a							+	+	
ab									+
BASIDIOMYCETES									
							+	+	
a		+		+					
a				+	+	+	+		
		+							
a		+							
ac		+							
ac		+							
a		+		+					
							+		
a							+		
		+		+	+				
a		+							
a		+			+	+	+		
	+	+	+	+		+			
	+	+		+		+			
a		+		+	+	+	+		
		+					+		
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		+		+					
a					+				

a = First report on Alaska cedar.

b = Identification by A. Funk gratefully acknowledged.

c = Identification by R. Gilbertson gratefully acknowledged.

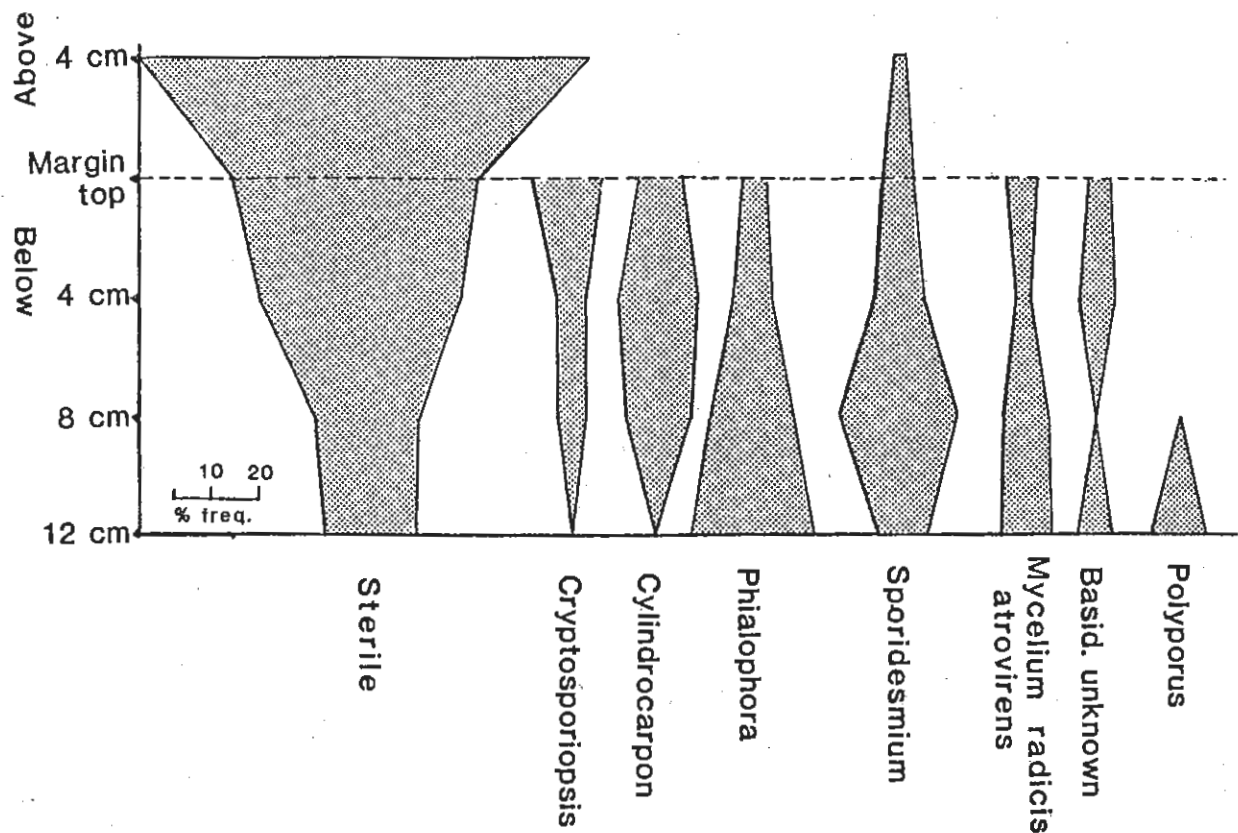


Figure 1. Distribution of fungi commonly isolated above, at the top, and several distances below the top of the margins of stem lesions on declining cedars. Frequencies are based on 253 isolations. Fungi comprising less than 2% of the isolates include: Gelatinosporium, Speggazia, Sporothrix, Dictyosporium, Verticillium, and an unidentified Basidiomycete.

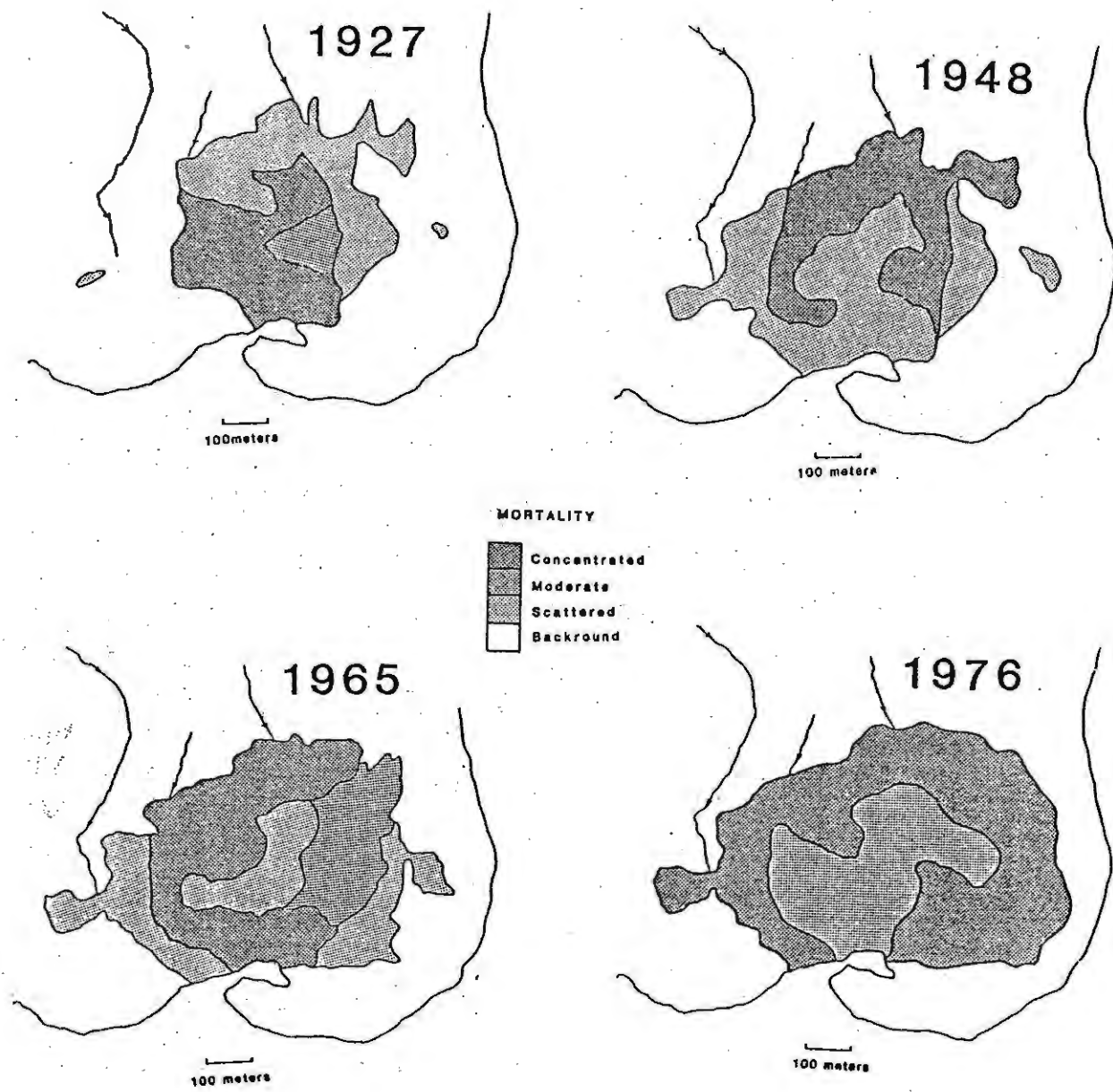


Figure 2. Maps of mortality at the Poison Cove site made from 1927, 1948, 1965, and 1976 aerial photographs.

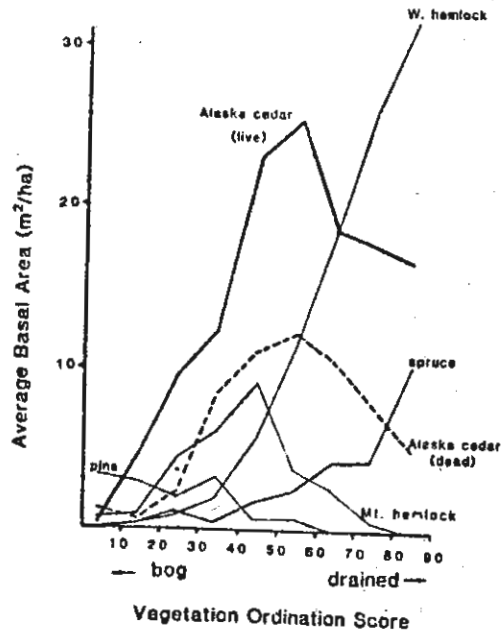


Figure 3. Average basal area of conifers across the gradient from bog to better drainage. Results are based on 280 plots.

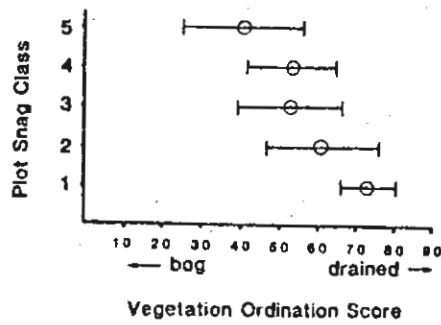


Figure 4. Average plot ordination score (bog to better drainage) for plots with different median (most common) snag classes. Snag classes were based on degrees of foliage, twig, and branch retention. Class 1 snags died recently ( $\bar{x} = 3$  yrs) and class 5 snags died long ago ( $\bar{x} = 81$  yrs). Results are based on snags from 280 plots.

EFFECTS OF COMANDRA BLISTER RUST ON  
GROWTH AND SURVIVAL OF LODGEPOLE PINE

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Comandra blister rust is a serious stem canker disease of hard pines caused by Cronartium comandrae. The life cycle of this obligate, macrocyclic parasite is completed on two hosts, Pinus and Comandra or Geocaulon. On pine, infections occur through needle and shoot stomates; hyphae grow intercellularly in the inner bark; and aecial sporulation induces cankering. After a diseased branch or bole is girdled, distal portions die, leaving either a flagged branch or spiked top. Serious damage--mortality and reductions of growth, quality and cone production result from substantial crown mortality.

A damage survey identified comandra blister rust as the most important disease on the Wind River District, Shoshone National Forest, WY. On the commercial forest, 30% of the basal area was lodgepole pine and 50% of that was affected by comandra blister rust. The disease was most common in stands of saw timber-size lodgepole pine. Most cankers were several decades old and had already girdled the bole and killed the top third of the crown.

Additional research has quantified the effects of rust cankers on the growth and survival of lodgepole pine. Specifically, three questions were addressed 1) which branch cankers are likely to become bole cankers, 2) which bole cankers are likely to be lethal, and 3) how much additional growth can be expected from spike-topped trees. Also, a damage rating system based on canker height was developed.

The progression of cankers from their origin on a branch into the bole and around the trunk was measured by monitoring or dissecting over 200 cankers. Mean annual branch canker extension rate toward the bole was 2 cm/yr. Year to year fluctuations in extension rate obscured possible differences in extension rate

due to either the size of the host stem, canker height or distance from infection origin to bole (infection distance). The percent of branch cankers which eventually became bole cankers decreased rapidly at infection distances greater than 15 cm. No cankers which originated on a branch further than 24 cm from the bole were able to develop bole cankers even after 10 years.

Mean annual rate of canker expansion around the bole (left plus right) was 4 cm/yr. In a four year study of saw timber-size lodgepole pine, rodent gnawing, tree size and canker height had no significant effect on the rate of expansion, although year to year variation was significant. The average number of years from establishment of a stem canker until top-kill can be more easily estimated from stem diameter (at canker center) than from circumference. For each centimeter of bole diameter approximately one year is required for spike formation.

To determine which cankers are likely to be lethal, a sample of 1597 lodgepole pine girdled by comandra blister rust was divided into two survivorship groups--killed and spiked. Trees less than 13.5 m tall or with a canker less than 8 m from the ground were more frequently killed than spiked. The proportion of killed trees was adequately described by a linear function of canker height ( $R^2 = .91$ ; proportion killed =  $.99 \times -.074$  canker height, m).

Stem analysis was used to determine the annual volume growth of 126 lodgepole pine cankered by comandra blister rust. Tree ages when the bole became cankered, girdled or spiked were estimated from stem sections removed at canker center, top and bottom. Compared to a 10 to 20 year period before canker age, annual volume growth was only reduced by 2% each year until the upper crown died. The greater the relative amount of crown mortality, however, the greater was the growth reduction after top-kill. Because cankers generally occurred lower in younger trees, growth reduction was most serious in trees less than 60 years old. The maximum annual volume loss observed in a living but spiked tree was 7% per year.

Several regression models were derived to project annual growth loss from comandra blister rust. Loss was defined as difference between the actual volume of a cankered tree and its projected volume from growth before infection. A relative annual loss was also calculated as the ratio of annual loss to projected volume. Loss was significantly correlated with spike length; age when cankered and stem length; relative loss was significantly correlated with proportion of stem length which was spiked, canker height, and age when cankered. Two-thirds of the variation in loss and relative loss was respectively explained by spike length and proportion spiked. The relation between amount of crown mortality and growth loss could be used in stand growth models to improve volume projections in diseased stands.

The amount of comandra blister rust damage from mortality, growth loss and degrade can also be described by an index, the relative growth potential, which is also approximately a linear function of canker height (Fig. 1). The relative growth potential of spiked trees of a certain age is the product of their probability of surviving and their expected relative growth. Expected relative growth is the ratio between the expected volume projected from spiked trees, excluding cull volume, and the potential volume projected from noncankered trees. Relative growth potential ranges from 0 (total loss) to 1 (no loss). Because relative growth potential and canker height are significantly correlated, relative growth potential provides an index of how serious is a canker at a given height. Two ages at which relative growth potential could have been calculated are 1) ten years after the top-kill and 2) when the tree is 100 years old.

The relationship between canker height and relative growth potential provides a means of rating the canker severity. A comandra damage class (CDC) is defined by the height of the lowest canker expected to girdle the tree within the next 10 years. To facilitate height measurement and establish damage classes, canker height is determined only to the nearest 5 m or 1 log (16.5 ft).

A tree with no cankers expected to girdle the tree during the next 10 years is given a CDC of "0"; a tree with the lowest potentially girdling canker in the first log has a CDC = 1; a tree with a canker in the second, third, or fourth logs are assigned CDC's of 2, 3, or 4 respectively. A tree with a CDC of 1 is seriously damaged (relative growth potential after 10 years more growth = .2); a CDC of 2 is moderately damaged (relative growth potential after 10 years = .5); a CDC of 3 is lightly damaged (relative growth potential after 10 years = .8).

The relative productivity of an infested stand can be estimated from mean CDC of cankered trees and proportion of trees cankered. First, an average CDC is calculated using only cankered trees; then the corresponding relative growth potential is read from Figure 1 and multiplied by the proportion of trees cankered. That product is then added to the proportion of healthy trees to obtain the weighted relative growth potential of the stand.

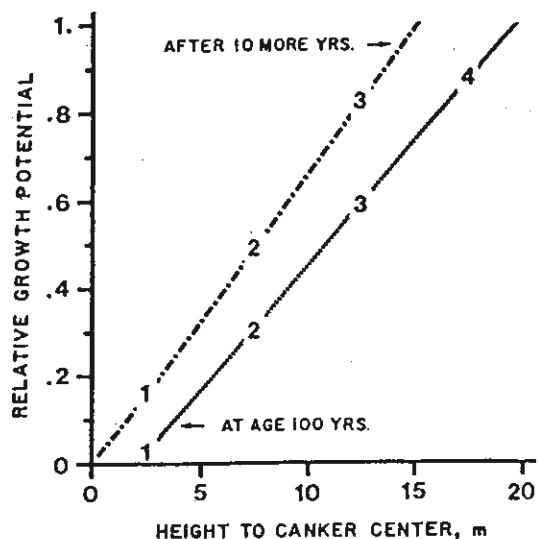


Fig. 1. Relative growth potential 10 years after top-kill and at age 100. Numerals indicate damage classes.

## REMOTE SENSING FOR DISEASE SURVEYS AND LOSS ASSESSMENT

William M. Ciesla  
INTRODUCTION

Remote sensing is the science and art of gathering data about a subject at a distance from that subject. Data is gathered in one or more regions of the electromagnetic spectrum; visible light, near infrared, thermal IR, radio waves, etc. A wide range of sensors, aerial photographs, multispectral scanners, thermal IR scanners, side looking airborne radar, etc.; and sensor platforms, balloons, helicopters, aircraft, and orbital satellites may be used to acquire the appropriate data.

### USES IN FOREST PEST MANAGEMENT

There has been widespread interest during the past two decades in the use of remote sensing technology in many phases of wildland resource management. Forest pest management is no exception. The human eye and photographic sensors, especially natural color and color infrared films, have been the most widely used in monitoring and inventory of destructive pests and pest complexes. Under certain conditions, effects of pest management tactics can be assessed using color and color infrared photography.

### AERIAL PHOTO ACQUISITION IN FPM

One of the major drawbacks to full scale implementation of color and color infrared photography in forest pest management has been photo acquisition. Pest damage is usually at its peak visibility for only a short time; therefore, the photo acquisition period is considerably shorter than for other applications of aerial photography. Availability of cloud free days for aerial photography is another limiting factor. Consequently, acquisition of aerial photography for FPM has traditionally not been attractive to contracting in the private sector.

To provide for timely, responsive photo acquisition in support of FPM nationwide, the FPM/Methods Application Group (MAG) has organized an in-service aerial photo acquisition program. This program is now in its second year and has been extremely successful. Several Forest Service Regions and at least one state forest service also have project level aerial photo acquisition capabilities which are available to their FPM specialists. Another photo acquisition capability that has been extensively used by Forest Pest Management is NASA's high altitude aircraft equipped with high resolution camera systems.

### DATA ANALYSIS

A number of approaches to data reduction and analysis are available for aerial photography and other sensor data. In certain instances, the image itself provides a sufficiently graphic representation of on-the-ground conditions without further analysis. This is especially true when using aerial photos to assess treatment effects. Several multistage sampling surveys have been developed to provide estimates of losses by a specific pest or pest complex. With proper sampling intensities, these surveys provide estimates within specified levels of precision.

Perhaps the most effective utilization of sensor data is through the use of geographic information systems (GIS). GIS permit retention of the spatial characteristics of photographic and other sensor data. They also provide for permanent storage of data. In addition, GIS provide for integration of other data with related resource information for pest impact assessment.

During the past three years, there has been increased utilization of aerial photo survey techniques in forest disease assessment nationwide. Multistage aerial photo/ground surveys have been used to estimate root disease loss in many areas of the western United States. An inventory of decline and mortality of American beech caused by the beech scale/Nectria complex (beech bark disease) was recently completed in West Virginia. High altitude panoramic aerial photography has been used to map groups of dead and dying Texas live oak in central Texas. An extensive inventory of red spruce and balsam fir decline and mortality, using medium scale color-IR aerial photos is underway in New Hampshire, northern New York, and Vermont.

#### PHYTOPHTHORA BLIGHT AND CANKER OF ABIES SPP.

Arthur H. McCain and Robert F. Scharpf

A serious twig blight and canker disease of Abies concolor and A. magnifica was shown to be due to Phytophthora citricola. The disease was found in a Christmas tree plantation near Pollock Pines, California where A. concolor occurs naturally. The fungus infects current season immature shoots and may move down the shoot into the trunk. Circumstantial evidence suggests that the fungus is carried in the ditch irrigation water which is applied by sprinklers.

The disease was reproduced in the greenhouse, lathhouse and field using zoospore inoculum. In the field the disease was reproduced by spraying zoospores on tender shoots in the late afternoon on May 30, 1984. Covering the shoots with polyethylene bags for 12 hours increased the number of infected shoots but was not essential for infection. A. magnifica appears to be more susceptible than A. concolor. Symptoms of the disease have been reported from two additional Christmas tree plantations where overhead irrigation with creek or ditch water is used. Control strategies will be evaluated in 1985.

#### THE EFFECT OF LIRULA ABIETIS-CONCOLORIS ON WHITE FIR CHRISTMAS TREES.

Robert F. Scharpf

A widespread but uncommon disease in the west caused by the fungus Lirula abietis-concoloris was found in epidemic proportions in 1982 in a plantation of white firs (Abies concolor) in the foothills of the Central Sierra Nevada, California. These firs were grown for Christmas trees. Unusually cool, wet weather conditions in spring and summer of that year appeared to account for the outbreak of disease. The fungus infected the newly developing foliage, and by 1983 nearly all the 1982 needles on many trees were infected and killed. Fully mature fruiting bodies had developed on infected needles and spores had been dispersed by fall 1983. Very little infection was observed on older needles and on 1983 foliage; thus the outbreak was limited to 1982.

The disease appeared to have had no measurable effect of either radial growth or height growth of trees in the 1982 and 1983 growing season. Persistence of the dead infected foliage on branches in 1983 made the firs unmerchantable as Christmas trees. If no further outbreaks occur and if dead foliage is shed, however, the infected firs would be suitable for Christmas trees.

ASSESSMENT OF PEST-CAUSED LOSSES ON A  
NATIONAL BASIS

Richard S. Smith Jr., Moderator

Our current approaches toward making estimates of pest-caused losses on a national scale, appear to date back to the Forest Pest Management meeting at Marana Park in the early 1970's. The consensus of the participants at this meeting was, that our old systems of estimating and recording losses were both inaccurate and inappropriate -- they reported losses and accomplishments in vague terms which could not be converted either to resources lost or to dollars lost. And, the participants concluded, in order to make sound defensible pest management and pest research decisions, at all administrative levels, we needed to develop methods of obtaining more accurate and meaningful estimates of pest-caused losses.

This meeting was held and the decisions were made at a time when social, economic, and political conditions were quite different than they are today. Looking back it appears to be an era of big projects, plentiful funds, and large staffs -- a time of abundance. Such projects were deemed to have a high priority, and half our staff would be tied up most of the summer and fall conducting pest-caused loss surveys.

I can not speak for other organizations or areas who are concerned about obtaining data for national loss estimates -- but in our corner of the world, smaller budgets and staff reductions have changed our priorities and greatly reduced our capacity to conduct the large loss estimating projects we were doing 6 to 7 years ago. So, we can no longer conduct the kinds of surveys which grew out of the Marana Park Meeting.

The fact is, that not conducting these regionwide loss surveys is both worrisome and a relief -- worrisome, because we have only limited current data on which we can base our loss estimates and we see no way of

getting more data; and a relief, because a large part of our staff is not tied up in general surveys and is now available to service our customers, the forest managers.

I do not believe that our staff is unique in its concerns about the why, what, and how of doing national loss estimates. So, perhaps it is time we had another look at these questions.

In thinking about this subject several questions came to mind and the speakers I have asked to be on the panel to some extent reflect these questions. They of course may not have the same views as I and may wish to explore other areas of this subject.

The first questions I had were:

- What are the national estimates of pest-caused losses used for?
- What levels of accuracy are needed at the national level?
- What are reasonable (acceptable) costs and who should bear them?
- Where do loss estimates fit in the listing of national priorities?

I have asked Bob Loomis from the Forest Service, FPM Office in Washington to talk to these questions and to present his views on national loss estimates.

The next set of questions I had, were related to the collection of data and might best be answered by persons from the Regions, Areas, or Provinces. These questions were:

- What kind of loss information is currently collected?
- Where do loss estimates fit in this groups priorities?
- Is the step wise aggregation of loss data, from the smallest management unit to the national level a reasonable or practical approach toward estimating national losses?

- What kinds of losses are important to collect: tree mortality, growth loss, degrade, decay, hazardous tree, etc., and in what kinds of units?

I have asked Sue Hagel, Region I, Forest Service; John Muir, Ministry of Forests, British Columbia; and Jim Hadfield, Region 6 Forest Service to give us their perspectives on national loss estimates.

Another important question I had was:

- Who should collect the pest-caused loss data needed to make these loss estimates; the forest pest specialist or the resource specialists?

Chuck Bolsinger a resource survey specialist from the PNW Research Station is here today to give us his views, ideas, and experiences on resources specialists collecting pest-caused loss data.

#### ASSESSING FOREST DISEASE IMPACT IN REGION ONE: A NEW DIRECTION

Susan K. Hagle, Plant Pathologist, Forest pest impact assessment in Region One has been approached using surveys for one or few pests at a time. Aerial surveys for bark beetles and defoliating insects (Tunnock 1978), roadside survey for dwarf mistletoes (Dooling 1979), and subcompartment sample surveys for dwarf mistletoes (Dooling and Eder 1981), and root disease (Williams and Leaphart 1978; James and Stewart 1981 and 1983) are examples of these. They have provided impact estimates for forest level and Regional reporting (McGregor et al. 1979, McGregor 1982, Byler 1982). However, with the exception of yearly aerial surveys for insect infestations, they lack sufficient resolution to be useful for district-, compartment-, and stand-level management.

We have also used permanent and semi-permanent plots to follow the development of diseases and insect populations over time. The dwarf mistletoe assessment program began with roadside surveys to ascertain distributions Regionally. Then subcompartment sampling was done to measure severity of infection, and finally permanent plots (Dooling 1970) were in-

stalled to measure growth loss and spread. Acreage infested and annual volume loss was calculated for each National Forest in Montana, and for part of north Idaho to meet national and Regional reporting requirements.

Data from dwarf mistletoe projects also have been used to produce models of growth loss and spread of dwarf mistletoe in trees and stands in Region One. The models will be linked with the PROGNOSIS Model developed by Al Stage and company at the Intermountain Forest and Range Experiment Station in Moscow, Idaho (Stage 1973). For a discussion of this project, see the paper by Mike Marsden in these Proceedings.

Root disease assessment also began with large scale, low resolution surveys using subcompartments to estimate acres of commercial timberland on National Forests which are in root disease pockets (Williams and Leaphart 1978; James and Stewart 1981 and 1983). Surveys of this type were accomplished on five National Forests in northern Idaho and western Montana. The data did not reflect volume lost nor account for stocking reduction in stands with scattered mortality. We returned to measure annual volume losses to root disease in two of the Forests by sampling the subcompartments for volume in current mortality (Stewart et al. 1982). This included not only those parts of the subcompartments in root disease pockets but also scattered mortality where at least one dead tree per acre could be seen on aerial photography. These efforts, spanning a 10-year period beginning in 1972, were successful in drawing attention to the importance of root diseases in Region One forest management (Byler 1982). However, we are still faced with the need to obtain information to directly aid in stand management (Byler 1984). To do this, we felt we needed to have a means to quickly assess losses in individual stands and to project probable consequences of treatments. This information would be used both for sale plans and for detailed Forest plans. We needed a way to hazard rate or, more importantly, risk rate stands under various management regimes.

Some sketch mapping of root disease centers was done during aerial surveys to provide information on the "where" of root disease concentrations, but they provide too limited information.

Special funding from FPM provided the means to conduct an intensified stand exam in 1983 on the Crow Creek drainage of the Thompson Falls Ranger District, Lolo National Forest. The goal had been to gather sufficient root disease distribution and damage information about the drainage to risk rate stands in the compartment as a vehicle for sale planning. We are also analyzing the data to calculate net impact of root disease during the current rotation. Stocking and volumes in root disease-affected and unaffected stands are being compared to determine yield reductions attributable to root disease. We have not analyzed the data sufficiently to ascertain whether this approach will work. However, it appears that a more accurate estimate of annual mortality rates under varying stand conditions will be needed to substantiate assumptions regarding the role of root disease in determining stand production.

To this end, in 1984 we established the Fernan project (Hagle 1984). This project uses a compartment exam design combined with semipermanent plots in a 3,000-acre drainage of the Fernan Ranger District, Idaho Panhandle National Forests. Stands in the compartment were stratified according to species composition and volume. They are all the same approximate age - 80 years. Sixty stands were selected. One-third of these will be commercially thinned. The plots were given ratings on a scale of 0-9 according to root disease severity. The trees on the plots were each given a root disease rating on a scale of 0-3 according to the current stand exam procedures for Region One. Yearly re-examination of the plots will monitor new mortality. All stands in the compartment will be assigned root disease impact ratings on a 0-9 scale using true color aerial photographs. Post stratification of the stands with these data will be used to analyze relative volume and mortality rate trends within and among the strata.

Projects which provide additional data are Charity and Ducharme (Dubreuil and Becker 1981). These are monitoring rates and patterns of root disease development following commercial thinning using stem-mapped, three-quarter acre plots. Sula and Schooner projects also address the commercial thinning problem, but in these stump size and species, and distance from stumps to susceptible trees are examined.

Regeneration permanent plots have been established over much of the Region. In this project, relative mortality rates in various tree species is being assessed as well as precommercial thinning effects.

While each of the current projects are designed to answer specific management questions, the data will describe relationships useful for constructing a root disease model as well. The model will be stand-specific and work with the PROGNOSIS Model much as described for dwarf mistletoe in this Region. Through hazard or risk rating, the model will account for volume lost and project yields under various management systems. This will provide the type of information needed for sale planning and Forest planning.

For Regional reporting also, we expect to use the model with subcompartment sample information and some additional subcompartment photo stratification to further refine estimates of Regional root disease impacts.

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PEST LOSS INFORMATION NEEDED  
AT THE NATIONAL LEVEL

Robert C. Loomis 1/

At the national level, information on pest losses is used for developing and justifying programs and for answering a variety of other requests for forest pest-related information from Congress, the public, and a variety of public and private organizations.

BUDGET

The process by which programs and supporting budgets are approved includes a series of decisions and compromises beginning at the individual staff units and progressing through the Forest Service, the Department of Agriculture, and the Office of Management and Budget. This process continues as the Congress considers the Administration's proposed program. If all goes well, final agreement is reached and the fiscal year's budget is signed into law by the President.

Unfortunately, well-documented arguments supporting specific programs are only one part of the decision process. Harsh budget realities, philosophical differences, politics, and numerous side issues exert great influence. However, two points are clear: weakly justified programs eventually are reduced or eliminated; conversely, well-justified programs have a better chance for survival or growth.

RESPONSIVENESS TO INFORMATION  
REQUESTS

Responsiveness to Departmental and Congressional requests for information is an important Forest Service requirement. Experience has shown that decisions influencing our programs will be made with or without accurate information. Self-preservation seems to dictate that we fully respond to questions regarding our programs in a timely manner. Also, agency credibility is at stake. If we are perceived as being uncooperative or as providing unuseable or inaccurate information, other sources, such as forest industry or various single-issue organizations,

may be asked to provide the background information on issues that directly affect our programs. Finally, being responsive to the general public continues to be a high-priority goal. One benefit of answering these requests for information--important issues are sometimes identified early enough to resolve.

AVAILABLE INFORMATION

The pest loss information we use comes almost exclusively from Regions and cooperating States. The annual Forest Insect and Disease Conditions Report is compiled from regional status reports. Special attention is given to 12 major forest pests, including the dwarf mistletoes, root diseases, and fusiform rust. The goal is to report pest outbreak status by acres infested for National Forest, other Federal, and State and private ownership classes. Regions are able to provide this information fairly well. The next step is to more completely estimate and summarize both the volume of timber killed and the growth loss for these same major pests. Forest Survey data provide an estimate of average annual unsalvaged mortality from all causes, of which we estimate that about 60 percent--or 2.4 billion ft<sup>3</sup>--is forest pest related. Forest survey also provides potential opportunities for quantifying the losses of some important pests. For example, this is being done for fusiform rust in the Southeastern United States.

FUTURE NEEDS

Although available information on pest losses may have been sufficient to justify our Research and Forest Pest Management Programs so far, in the future we will need to better explain not only how damaging pest problems have been but, more importantly, we must document the progress being made in reducing pest-caused losses. In short, we need to better explain how continued support of our programs is warranted based on the resource values we protect.

1/ Plant Pathologist, USDA Forest Service, Forest Pest Management, Washington D.C.

OPINIONS ON ASSESSMENT OF PEST-CAUSED  
LOSSES ON A NATIONAL SCALE BY A PACIFIC  
NORTHWEST REGION FOREST PATHOLOGIST

James S. Hadfield  
USDA Forest Service  
Pacific Northwest Region  
Portland, Oregon

I believe there is a legitimate need for National statistics describing pest-caused losses of our forest resources. I believe we should match the costs of our efforts to collect these data to the values we realistically expect to realize from their use. I believe this has generally not been accomplished in many past forest pest impact assessment efforts on a Nationwide, regionwide, and statewide scale.

The Washington Office of the Forest Service obviously is not going to do any National-level pest impact survey on their own. They will ask the Regions to collect the data, then they will add together the input to come up with National pest losses. So let's talk about regionwide loss assessment with the understanding there will have to be some uniformity of methods and reporting formats.

In order for us to muster much enthusiasm for doing regionwide pest loss assessments, there must be some valuable uses for the information. I have identified the following uses for regionwide pest loss assessment statistics.

1. Respond to Washington Office requests for statistics for regional and National losses.

2. Inform the general public, especially students in elementary and high schools, about the magnitude of pest-caused losses.

3. Respond to data needs of the Resources Planning Act and Regional Plans for the National Forest Management Act.

4. Provide data to state legislators to justify budgets for state Forest Pest Management programs.

5. Provide data for top-level land managers to indicate the significance of pest problems.

Regionwide pest loss assessments will not be used to shape the structure or program of the FPM staff. The activities and structure of the FPM staff are dictated by the number and nature of requests from our customers who, in our specific case, are overwhelmingly Federal forest land managers in Oregon and Washington. If our staff was a reflection of the pest-caused losses, most of us would be working on stem decays since they cause the most dollar or value loss in our Region.

Regionwide pest loss assessments do not directly help us or ultimately our forest manager clientele to effectively manage disease in a specific stand. What does it mean to a forester on the Alsea Ranger District if you tell him the Region experiences an annual loss to root diseases of 132 million cubic feet? Not much! On the other hand, what does it mean to him if we tell him 51 percent of the trees in his 20-year-old precommercially thinned stand are dead and dying and the infestation occupies 75 percent of his plantation? It tells him to abandon the plantation and start over.

Assessing pest losses on a region-wide basis is rated low priority in the Pacific Northwest Region, especially if we have to do special surveys to collect the data. We can already rank the relative importance of diseases and insects in the Region. We have

previous loss assessments such as the 1967 Childs and Shea report that can be updated at minor cost.

We know stem decays cause more volume loss than other pests. We know root rot losses are probably of the same general magnitude as losses associated with dwarf mistletoes. We also know it does not make much difference in a region that annually produces about 16 billion board feet of timber whether our estimate of annual root disease losses is 132 million cubic feet or 120 million cubic feet or even 100 million cubic feet. Regardless of which number is truly correct, the losses are very large and to determine which number is correct would require a lot of money and the usefulness of the number would be no better than our inexpensive professional opinion.

I am not even remotely suggesting that we merely guess at the losses without any basis for our estimates. Our professional integrity will not allow us to slop our way through. We need to clearly keep the costs of data collection in line with the value of the information. Lets not earn a golden fleece award by spending \$200,000 for a \$200 number. Let me ask a question. Do you think a Congressman would want us to spend more than \$500,000 to determine the annual impact of dwarf mistletoe with an accuracy level of plus or minus 10 percent or would he be happy with a \$5,000 estimate accurate to within 20 percent?

At the present time, the R-6 FPM staff is not capable of conducting region-wide statistically valid loss assessment field surveys for diseases. It is not a question of lacking the talent, because we definitely have that. We do not have the time or the inclination to do such surveys. The top priority of the pathologists in the Pacific Northwest Region is to

respond to our clients' requests for site-specific biological evaluations and to provide training to enable them to better manage forests for protection against disease losses. There is no hue and cry for regionwide loss data from our customers. Forest Pest Management is a service organization; if we don't satisfy our customers' demands, our report cards will quickly reflect their dissatisfaction. We do not have the funds to contract someone else to do regionwide loss assessment surveys, even if this were top priority

Our capabilities for making Region-wide loss assessments are limited to office updates of previously published estimates, usually Childs and Shea. We can make estimates of losses due to stem decays and dwarf mistletoe from forest inventory statistics. Likewise we can estimate total tree mortality from all causes from the forest inventory.

I believe the best approach to developing regionwide loss assessment should be to start at the lowest common denominator the individual stand and work upwards. Information should be useful for site-specific prescriptions and for the big political decisions. It would not be possible to develop good regionwide loss estimates using stands surveyed by FPM for the data bases because the stands we typically see are the most severely affected. If we were to use them, we could greatly overstate the impact of pests.

My suggestion is to integrate pest surveys into stand and forest inventories. Do not do single pest surveys because the total of losses attributable to individual pests would undoubtedly exceed the real total. In the Pacific Northwest Region, there are two levels of resource surveys that collect pest data. Data from both are stored on computers for relatively

easy retrieval. The stand examination collects data for prescriptions within individual stands. Data collectors have a list of major pests they most look for and record if they are present. The degree of infestation is recorded. The other survey is the forest inventory, which is done on a forestwide and countywide basis. These surveyors are also supposed to record the presence of pests. I see two problems with relying upon these surveys for developing Regionwide loss assessments. First, the surveyors have to be trained to accurately identify pests. We are dealing with this by training the survey crews. The second problem is there has to be a commitment to using the pest data for real needs. Data collection is expensive--if we don't need it, don't collect it. My feeling is we could over a 10-year time period accurately estimate pest losses on a regionwide basis by extracting and analyzing the data from these resource surveys. This could be done at a minor fraction of the expense that it would cost pest management organizations to do these surveys.

Hagle con't

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PEST IMPACTS AND FOREST MANAGEMENT  
IN BRITISH COLUMBIA

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One of our major concerns in developing a forest pest management program in British Columbia has been to determine the impact of pests on forest resources.

Forest pest management, i.e., management of forests to prevent or reduce damage from pests including diseases, requires estimates of pest-caused losses and of gains or reduced losses expected from pest management activities. In this paper I want to review briefly and generally our concerns with pest impacts in B.C., recent accomplishments and efforts currently underway.

Our mainstay in determining forest pest impacts in B.C. has been the Canadian Forestry Service (CFS) Forest Insect and Disease Survey (FIDS). They have provided general estimates of impacts, survey methodology, pest surveillance and advice on forest pest management in specific areas.

A substantial increase in B.C. forest pest management program in 1980-81 resulted from incorporation of these general estimates of pest impacts into the first Ministry of Forests regional resource analysis program. Estimates of pest impacts in B.C. by CFS-FIDS were applied to the six regions of the province, and general goals for pest management, in terms of timber volume per year, were stated. As a result of the analysis, specialists and coordinators were employed at Protection Branch, Victoria and at region and district offices in much of the province.

A second major concern of forest pest impacts in B.C. has been the recent

enormous increase of bark beetles - mountain pine beetle and spruce beetle. Ministry aerial and ground surveys were intensified and extensive CFS-FIDS surveys were supported. In response to the pest impact survey data, an emergency bark beetle control program was appropriated amounting to \$11 million for a two year period. Unfortunately the emergency funding was curtailed due to the recent depression and government restraint measures. However more recently on the basis of further surveys, analyses and submissions, additional funding has been provided to address beetle priorities.

Another major concern in B.C. has been impact of Phellinus root disease in coastal forests of second-growth Douglas-fir. As a basis for their pest management program, Vancouver Forest Region undertook an intensive, region-wide survey of 500 stands each 20 ha or more, using a line-intercept survey method and data analysis program developed by CFS researchers. The results indicated that almost all stands had some Phellinus with an average of 10-15% of the stand area with trees visibly infected.

The calculated impact of root disease in each of the surveyed timber supply areas is substantial. For example in the Quadra TSA the estimated timber volume loss based on the infected stand area and the average mean annual increment, was 123,000 cubic meters per year on good and medium sites. This volume is 12.5% of the current allowable annual cut from the TSA. These survey data, which are being incorporated into the TSA yield analyses, should have a major effect on forest management of second-growth coastal Douglas-fir in B.C.

Another major concern has been pest impact data for each TSA. Recently we provided estimates of pest impacts mainly for planning purposes for each TSA based on CFS and Ministry data and on our best guesses where data were lacking. These estimates should facilitate future planning and analyses of timber yields.

Incorporation of pest impact data into the TSA yield analysis is another current concern. The Ministry is required to use computer-based models such as MUSYC and FORPLAN to calculate the effects of various rates of timber harvesting and levels of silviculture activity on short-term timber supplies and long run sustained yields. From the results of several analyses and other considerations, the Chief Forester selects an allowable annual cut which is harvested by license holders. Pest effects and other sources of depletion were accounted for in previous analyses sometimes to an unknown extent, by using empirical volume-age curves, i.e., those based on data from actual stands, an adjusted land base which excluded non-productive lands, and specific volume deductions believed to be equivalent to losses from pests and other causes. However we suspect that the dynamic effects of pest impacts on yields are much greater than their estimated percentages.

Results of a recent cooperative study by Dr. W. Reed, University of Victoria, and D. Errico, Ministry of Forests, indicated that when forest fire losses were incorporated into a forest stand yield model, the effects on yield were much greater than expected. For example in northern B.C. spruce forests where the historical loss was one percent of the stands burned per year, the average expected long-run sustained yield of timber per hectare of  $2.53 \text{ m}^3$  per year, the average mean annual increment, was reduced to  $1.49 \text{ m}^3$  per ha per year - a 40% decrease. The age at which mean annual increment culminated, which is used as the optimum rotation age in B.C., was reduced from 105 to 93 years. If harvesting were continued at an average rotation age of 105 instead of 93 years, the average timber yield would be reduced an additional 5%.

A whole-forest yield analysis model is being developed to incorporate fire losses. A preliminary analysis indicated that a probability of fire loss of 0.36 percent, which is roughly equivalent to our current rate of fire loss, would

reduce a calculated long range sustained yield of  $265\,000 \text{ m}^3$  per year without fire loss to  $220\,000 \text{ m}^3$  per year - an eight percent reduction. Thus a small incidence of fire loss could result in a substantial impact on forest production.

A preliminary application of this type of analysis to mortality from mountain pine beetle in the Williams Lake TSA indicated that the impact of current losses might be  $830,000 \text{ m}^3$  per year, more than 10 times than the current allowance  $62,000 \text{ m}^3$  for insect and fire losses in the TSA.

This type of analysis also might be suitable to analyze some of the impact of root disease losses in coastal B.C., and preliminary work by CFS and Ministry personnel is underway.

Theoretically growth losses from diseases should be easier than mortality losses from fire and insects to incorporate in TSA yield analyses by modifying the volume-age curves used to calculate yields. Such pest-impact curves are needed for stands with and without disease, preferably at significantly different levels of disease incidence, and for stands which have received various control treatments.

One of the most likely pathogens to analyze in this fashion is dwarf mistletoe. We have contracted with John Laut to determine if the lodgepole pine dwarf mistletoe stand evaluation model LPMIST, now incorporated into RMYIELD, is applicable to B.C. conditions but the results are still uncertain. Dr. Bloomberg, CFS research scientist, is working with Dr. K. Mitchell, Research Branch, to incorporate the hemlock mistletoe model into the Ministry's managed stand yield model for western hemlock.

Incorporation of coastal root disease survey data into yield analyses is needed, and Vancouver regional personnel are working on this problem. We need to incorporate data not only on the incidence of infected stand area but also on the

other substantial effects of Phellinus such as rates of tree mortality, reduced volume growth and increased windthrow of infected trees, and occupation of productive sites by brush or other less-productive tree species. We also need to estimate the impacts of control treatments such as mechanical stump removal, planting alternative tree species such as western white pine and effects of other options on forest productivity.

Analyses of disease impacts on forest productivity also is needed for other diseases which are or could be important, such as Heterobasidion (Fomes) annosus in coastal B.C. and Polyporus tomentosus in interior spruce forests. Work is underway on these diseases by CFS, Ministry and University of B.C. personnel. Further work to determine suitable evaluation methods are needed for other diseases such as plantation stem diseases and foliage diseases which again have been widespread and severe in recent years.

Programs to protect forest from fire and insects have been prominent and well supported in B.C. because of their obvious rapid effects on mature forests. Although recent CFS-FIDS and MOF estimates indicated that forest losses due to diseases overshadow those to fire and insects combined, disease effects have been relatively inconspicuous, long-term and often unrecognized. General estimates of disease impacts which are useful at a broad planning level need to be refined or applied in more detail. We need to incorporate disease impacts explicitly into yield analyses to demonstrate their effects on forest productivity and show what benefits can be realized from disease management. Then disease impacts will be directly relevant and well integrated in our forest management programs in B.C.

Chuck Bolsinger

The Nationwide Forest Inventory and Analysis Project includes numerous permanent plots on all types of land ownership. The plots are visited every 10 years, which is a weakness, for more could be gleaned by more frequent visits, particularly to establish causes of mortality. In a 1972 California loss study, causes were: 23% insect, 16% weather, 11% disease, 4% logging, 4% suppression, 3% fire and 9% unknown. However, instead of checking for root rots, all windthrown trees are classified as weather losses. With greater awareness, training and manuals the effects of many pests could be recognized and the losses more accurately noted and the plots could have considerable use (notes by editor, with considerable help from G.A. Van Sickle).

FOREST DECLINE IN CENTRAL EUROPE AND THE SOUTHERN APPALACHIAN  
MOUNTAINS: OBSERVATIONS AND RESEARCH

**A Statement Prepared for Presentation to the  
United States House of Representatives**

**Committee on Health and Commerce  
Subcommittee on Health and Environment**

**Dr. Robert Ian Bruck, Associate Professor**  
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**INTRODUCTION**

My name is Robert I. Bruck. For the past five years I have been an Assistant Professor of Plant Pathology and Forestry at North Carolina State University. I am a specialist in diseases of forest trees. An important part of my personal research has been concerned with decline of the boreal mountain spruce and fir forests of the Southern Appalachians.

Recently, I returned from an intensive week of field excursions at six locations in central and southern West Germany. This excursion was a carefully planned exchange of 18 West German, Canadian, and United States scientists concerned with regional changes in the growth or behavior of forests in central Europe and eastern North America.

This exchange of scientists was sponsored by the West German Ministry of Research and Technology and the United States Environmental Protection Agency. It was organized through the Acid Deposition Program at North Carolina State University.

Our verbal and written testimony at these hearings is based on research observations by all three of us and on communications with Drs. Peter Shutt, Bernard Ulrich, Karl Rehfuess, Bernhard Prince, Karl Krentzen, H. Zottl and others in West Germany, during the past nine months but especially during the weeks of September 15-21, 1983 and May 15-22, 1984.

**FOREST DECLINE IN CENTRAL EUROPE**

"Waldsterben" or forest decline is a rapidly developing pattern of changes in the appearance and behavior of forests in many parts of Germany and other central and eastern European nations. The symptoms of decline are not identical in rate or sequence of development in various species of trees. Nevertheless, they

include the following features, some of which have never or only very rarely been reported before in the literature of forestry and plant pathology.

Changes in the forests have developed very rapidly and unevenly but roughly simultaneously since 1979. Symptoms of decline have been observed in many different species and types of forests, principally silver fir (Abies alba Mill.), Norway spruce (Picea abies Karst.), European beech (Fagus sylvatica L.), and Scotch pine (Pinus sylvestris L.), but also including red maple, white oak, larch, white birch, alder, and white ash. The symptoms include a general thinning, change in color and altered morphology of the leaves and total tree canopy, particularly in spruce, fir, beech and pine. Loss of foliage is common in both spruce and fir. A loss or sparse development of foliage and abnormal development of branches are common in European beech. The formation of smaller than normal leaves, especially in beech and spruce, and misshapen (lobed) leaves, especially in beech, have been noted.

Active casting of green leaves especially in beech, fir, spruce, larch, alder and oak and of green shoots with intact leaves and needles, most notably in spruce and pine and occasionally in oak have also been observed by German scientists. A decrease in diameter growth, particularly in fir and spruce during the past 20 years, has been noted. In spruce and fir the width of annual rings in affected trees has been found to be greater high up on the stem and much reduced or absent toward the base of the stem. This kind of abnormal distribution of annual increment has rarely been reported before.

Abnormally heavy cone and seed crops have been observed three years in a row in spruce, pine and beech. This has not been reported in silver fir. Unusually large numbers of adventitious shoots are formed on affected spruce; epicormic branches are common on affected European beech trees. The complete lack or great suppression of fine feeder roots and ectomycorrhizal roots, a symbiotic association of fine roots and beneficial fungi, has been observed. This poor development of fine roots is especially common in affected beech, but is also less common and not as intense in spruce and fir.

Wood, most notably of branches, has become unusually brittle in affected beech trees. Marked deficiency of magnesium has been confirmed in the foliage of affected spruce trees. Death of most or all of herbaceous vegetation immediately beneath the canopy of some affected trees has been observed in two locations in Bavaria. The formation of crystals of calcium sulfate in the stomata on needles of affected spruce have been observed by electron microscopy. This wide array of symptoms has developed very rapidly (since 1979) and is so widespread in occurrence that many private,

industrial and government foresters in West Germany are concerned that the forests as they have known them may not survive.

In seeking to understand the possible causes of forest decline in Central Europe it is important to note that trees growing on fertile or infertile soils, in both basic and acidic soils, are affected by "Waldsterben." In forest stands regardless of aspect or orientation in southern Germany, and particularly in Bavaria but more commonly on northwest-facing slopes in northwestern Germany, north Rhine Westfalia and on west-facing slopes on elevations above 100 meters in the Black Forest area of Baden Wurtemberg have been most severely affected.

Although the most severe symptoms have been reported at high elevations, 800-1400 meters and above, essentially similar symptoms have also been observed in forests at moderate and low elevation sites. The first survey conducted in 1980 to delimit the geographic extent of forest decline in Germany indicated that approximately 8% of the total forest area were affected. A more comprehensive survey in 1983 indicated that 34% of the Germany forests are showing some stage of forest decline.

Several hypotheses have been proposed on the cause of forest decline including gaseous pollutants, magnesium deficiency induced by atmospheric deposition, general stress resulting from a combination of pollutants and drought, acidification of forest soils causing aluminum toxicity to the roots, and other biotic and abiotic stress factors.

Over the past 20 years red spruce (Picea rubens Sarg.) located in the high elevation forests of New York, Vermont and New Hampshire have exhibited marked dieback and decline symptoms. Certain northern Appalachian red spruce stands are presently exhibiting in excess of 80% dieback incidence and 60% incidence of mortality. The decline is characteristic of a stress related disease, and the etiology is not typical of a single biotic pathogen. In November 1983, a preliminary survey of Mt. Mitchell, NC was conducted from the summit (6,684' MSL) to below 5,200' MSL to characterize and photodocument the presence of any decline or dieback of red spruce in the southeastern United States. Mount Mitchell is the highest peak in eastern North America and its main peak and three high altitude ridges support vast populations of red spruce and Fraser fir which comprise one of the largest sub-alpine ecosystems east of the Mississippi River. All trees sampled at or above 6,350' elevation regardless of vigor exhibited marked growth reduction beginning in the early 1960's. On numerous samples the 21 annual growth increments from 1962-1983 were equivalent in total diameter to the four annual increments of 1958-1961. Precipitation data from 1930-1983 show that at no time during these 53 years was there a drought at the summit of Mt. Mitchell. Therefore growth

suppression cannot be attributed to lack of moisture. In May 1984 a survey was begun to quantify and characterize the extent and rate of high altitude spruce-fir forest decline in the Southern Appalachian Mountains. Our preliminary analysis indicates that the forest syndrome is observed in varying degrees throughout the southern Appalachian Mountains. West-facing slopes appear to have greater decline and dieback incidence along with greater annual ring increment suppression, which is observed on an average of 82% of all sampled red spruce dominant and co-dominant trees. Preliminary soil analysis suggests higher loading of lead on west-facing slopes. A series of permanent plots has been established on eight high elevation peaks which will be periodically revisited to quantify the temporal and spatial dynamics of the forest decline.

## METHODS

Stand Selection. Twenty-five to one hundred year old stands were selected for sampling. The primary selection criterion was that the vegetational composition of the stand be representative of the community on a given aspect of a given peak as determined by visual inspection. The secondary criterion was that the tree canopy within the stand should be as intact as possible in order to obtain a sufficient number of live trees per plot for statistical analyses. As a consequence of the second criterion, selected stands typically exhibited the least Balsam wooly aphid impact for a given community. Contrasting stands were sampled at both high and low elevations on a given peak when an elevational difference within the spruce-fir zone of at least 150 m between high and low stands could be obtained.

Stand and Plot Establishment. Stands selected for sampling were 1-ha circular areas in horizontal projection. Decline and dieback assessments in each stand were made within three randomly located 30 X 4 m rectangular permanent plots. These plots were oriented radially around stand center at a random azimuth and distance, with over sampling of stand center minimized through a transformed random number table. A tape was laid out to mark the center line of a plot. Slope angle was determined with a clinometer and used to adjust plot length to 30 m horizontal distance. The sampling area of a plot extended 2 m horizontally on each side of the plot center line. Forty centimeter orange plastic survey stakes were used to mark the endpoints of each center line, as well as the center of the stand.

General Stand Description. After establishing the center point of a stand, a general description of the stand was written; this description included a list of the species in the tree and shrub layers and dominant species in the herb layer. In addition, the general slope and aspect of the stand, height of the tree canopy, indications of logging or fire and any striking topographic and

landform features, were noted.

Plot Description. Departures from the general stand description were noted for each plot. Arborescent individuals were classified as trees if their diameter at breast height (DBH) was  $> 10$  cm, as saplings if they were  $\geq 2$  m in height but  $< 10$  cm DBH and as seedlings if they were  $< 2$  m in height. Each live tree within 2 m of the center line of a plot was marked with a serially-numbered aluminum tag placed at 1.3 m from the ground. Height of tag location was determined as the average of two measurements taken along the contour on opposite sides of the tree. DBH of a tree was measured immediately above this tag. The location of each tree was recorded to the nearest 0.5 m along the long and short axes of the plot.

Species, DBH, crown class, and dieback and decline ratings also were recorded for each tree. Dieback and decline were only assessed on red spruce and Fraser fir. Dieback was assessed on a 10 point scale (1 = 0-10%, 2 = 11-20%, etc.) and was measured as percent loss of live crown length from the top and outside of the crown. Decline was assessed on a 4-point scale (1 = 0-10%, 2 = 11-50%, 3 = 51-90% and 4 = 91-99%) and was assessed as percent foliage loss from the lower, inner crown, upward. Percent foliage loss was determined by first estimating the proportion of crown length affected and then determining the number of years of needles retained within the affected portion of the crown. Normal needle retention time for red spruce was assumed to be 6 yr while that for Fraser fir was assumed to be 5 yr.

The presence of fungal pathogens, insects and mechanical breakage was noted for each tree. When evaluating fir trees, any tree which received a decline or dieback rating greater than 1 was checked for signs of the Balsam wooly aphid by examining the bole for the presence of wool and branches for the presence of gouting.

Two increment cores were taken from each of the 5 dominant and largest codominant trees on each plot. Cores were taken just below breast height on opposite sides of the tree along the contour.

All dead trees on a plot were recorded by species, if possible, and their diameter measured. Saplings were recorded by species and an estimate of height made to the nearest meter. For both red spruce and Fraser fir saplings, decline and dieback assessments were made using the same rating schemes as for trees. Estimates of seedling density for all arborescent species were obtained using six  $1 \text{ m}^2$  subplots placed 3 m outside the plot at distances of 8, 16 and 24 m along its long axis.

Soil Sampling. Soil samples were collected from each plot in a stand using a 22.5 cm X 22.5 cm aluminum template. The template

was located approximately 5 m downslope from the center of each plot in an area free of boulders and relatively free of large rock fragments to a depth of 12 cm. Typically soil was collected in 4 cm increments to a depth of 12 cm. An additional series of samples was taken from plot #2 in each stand by collecting the forest floor and the first 4 cm of mineral soil in separate bags. All roots and stones recovered in the sampling procedure were retained in order to estimate soil bulk density.

Soil Analysis. All soil samples were divided in half upon receipt in the laboratory. One half was stored at 4C without drying, while the other half was dried (65C), sieved (2 mm) and prepared for analysis.

Preliminary soil analysis for total heavy metal content from selected sites was performed using the procedure of Friedland et al. (1984). Future analyses will attempt total dissolution of soil samples using the following procedure: 1 gram samples will be weighed into silica crucibles, ashed for 12 hours at 475C, then quantitatively transferred to Teflon beakers. Approximately 5 ml of concentrated HCl and HF will be added and evaporated to dryness on a steam plate. This step will be repeated until dissolution of residue is complete. After this step, 2 ml of concentrated HCl will be added and the beaker contents quantitatively transferred to a 50 ml volumetric flask and diluted to volume with distilled-deionized water. Elements to be analyzed include K, Ca, Mg, Cu, Zn, Mn, Fe, Pb, Cd, Co, Cr, Ni, Al and Sn. N, P, S, and B will be determined on separate samples using published procedures (Page, et al., 1982). All results will be expressed on a 105C dry weight basis.

Appropriate quality assurance/quality control procedures and standard reference materials will be used during the analysis of samples.

## RESULTS

During the 1984 field season, permanent plots were established on six of eight mountain areas visited. The northernmost area studied was Mt. Rogers in Virginia. Moving southward, plots were established on Grandfather Mountain, Roan Mountain, Mt. Mitchell, Clingman's dome (GSMNP), and Mount Le Conte (GSMNP). The southernmost site visited was the Joyce Kilmer Wilderness area, however, permanent plots were not established at this site due to a lack of suitable stands of red spruce and Fraser fir. This was also true for the Plot Balsams which are located east of the Great Smokey National Park.

The frequency of decline for all low altitude sites between 5,200 ft and 5,600 ft is summarized in Fig. 1, while the frequency

of decline for all high elevation sites between 5,600 ft and 6,684 ft is summarized in Fig. 2.

A decline class rating of 1 signifies relatively healthy trees with a defoliation index of between 0 and 10%. As can be noted in Fig. 1, the average number of trees throughout the southern Appalachians showing a decline class rating of 1 is approximately 79%. It should be noted, however, that the west-facing slope of the respective mountainsides have a significantly greater amount of decline symptomatology with only 62% of the trees in decline class 1. Figure 2 illustrates the frequency of decline for all high elevation sites sampled. The average percent of the high elevation trees showing decline class 1, i.e., healthy trees, is generally less, with an average of 68% in this category. Only 54% of trees on west-facing slopes fell into decline class 1, thus indicating that approximately one-half of all high altitude trees exhibited some decline symptomatology.

Increment cores were removed from only dominant and codominant red spruce and Fraser fir trees. Figures 3-9 outline the results of this increment core analysis on Mt. Rogers, Roan Mountain, Grandfather Mountain and both high and low elevation sites on Mt. Mitchell. For the purposes of this report, the results from additional increment cores taken outside of established plots were included in Figures 3-9. On these mountains there was an abrupt and synchronous suppression of annual growth of both Fraser fir and red spruce beginning in a window period of approximately 1958-1965. However, we consistently found that red spruce was in a much more serious state of growth suppression than was Fraser fir in all sites. Perhaps the most abrupt increment suppression observed was on Mt. Rogers in Virginia. Although the amount of visible decline here was the least of the sampled sites, increment suppression was found in all the spruce sampled, with approximately a five-fold decrease in radial increment since 1960 as compared to the annual increments from 1950 to 1960. The overall frequency of red spruce increment suppression averaged approximately 82%. The lowest incidence of approximately 43% was found in the low elevation red spruce trees on Mt. Mitchell. It should be noted that the definition of severe increment suppression in this particular study is at least a 2-1/2 fold decline in the average annual increments of 1960-1970 as compared to 1950-1960. Virtually all red spruce trees showed a slowing of growth during this period; however, many natural factors such as the natural aging process can account for a relatively slower growth rate.

Figures 8 and 9 illustrate a comparison between high and low elevation sites and red spruce growing at east and west aspects on Mt. Mitchell. It is interesting to note that not only are westward-facing trees in a more severe state of decline as illustrated in Figs. 1-2, but there also appears to be a greater

amount of relative increment suppression in westward-facing trees as compared to eastward-facing trees. Although this correlates nicely with soils data showing higher amounts of loading of lead on the westward-facing slope of the mountain (Table 1), it is too early to conclude that in fact decline symptomatology and growth increment suppression are necessarily cause and effect related to the west-facing side of the mountain and hence the incoming atmospheric deposition. Many other natural phenomena such as wind damage and more severe temperatures may also account for the greater decline and increment suppression on the west face of the mountain.

#### DISCUSSION

I have presented in this report a preliminary analysis of a small part of the data collected by our survey during the past field season. As of the date of this meeting, work is still going on in the field and the laboratory to further characterize our permanent plots. Therefore, it is inappropriate at this time to attempt further evaluation of the data in Figures 1-9, and in Table 1.

#### CONCLUSIONS

1. Boreal montane forest tree decline of red spruce and Fraser fir in the southern Appalachian Mountains appears to be a real and quantifiable phenomenon.
2. Incidence of decline symptomatology is present throughout the southern high altitude mountains and may be more pronounced on west facing slopes.
3. Severe synchronous annual growth increment suppression in red spruce and to a lesser degree in Fraser fir has been documented for four sites in the southern Appalachian Mountains. Preliminary analysis indicates that more severe suppression may occur on west facing slopes, which correlates with both the incidence of tree decline and the presence of atmospheric deposition products.

#### OBSERVATIONS AND EXPERIMENTS WITH MYCORRHIZAE

Roots of spruce, pines and other needle-bearing trees usually show a symbiotic association with beneficial fungi. These fungus-root structures are called mycorrhizae (myco = fungus, rhiza = root). We observed a statistically significant correlation ( $P = 0.05$ ) between the percent of spruce short roots that are mycorrhizal and the elevation at which the tree was growing. Trees growing above 6,350 feet averaged about 35% mycorrhizal incidence and spruce at or below 5,200 feet averaged about 72% mycorrhizal

incidence.

When percent mycorrhizal roots were plotted against the degree of decline of the host tree, a highly significant correlation coefficient ( $P = 0.01$ ) was found. Trees exhibiting 80% or more defoliation (spruce at high altitudes) averaged about 30% mycorrhizal roots, whereas trees with few decline symptoms averaged about 75% mycorrhizal roots.

High altitude red spruce roots exhibited a far greater degree of disintegration (fine root necrosis) than did the creamy white, fungus mantle covered, tree roots found at low elevation.

Acid-rain simulation mycorrhizae experiments in greenhouses at North Carolina State University have demonstrated that incidence and vigor of loblolly pine were severely retarded at pH 4.0 compared to pH 2.4, 3.2, or 5.6. We believe this is the first significant biological effect to be documented at the pH of ambient rainfall for the state of North Carolina.

Mycorrhizal roots of red spruce at low and high elevations on Mt. Mitchell were very similar in appearance and state of necrosis to the pine roots in these rain simulation experiments and were similar in morphology and state of necrosis as compared to the pH 4.0 rain simulation experiments.

#### OBSERVATIONS ON ROOT-INHABITING FUNGI

Root isolations made from declining (high elevation) and non-declining (low elevation) red spruce roots revealed that at least two species of a fungal root pathogen named Pythium were frequently isolated only from the roots of declining trees. Roots of vigorous trees at low elevation often failed to yield any pathogenic fungi.

#### OBSERVATIONS OF FOREST REPRODUCTION

At altitudes above 6,350 feet we observed little successful fir, spruce, or shrub reproduction. The ground was barren of any living woody vegetation. Slopes on the mountain below this altitude showed normal reproduction--they were heavily colonized with seedlings and saplings of all age classes. By contrast, a vegetation survey in 1958 showed that all Mt. Mitchell slopes from the summit down had lush and abundant ground covers.

#### OBSERVATIONS OF TOXIC METAL ACCUMULATION

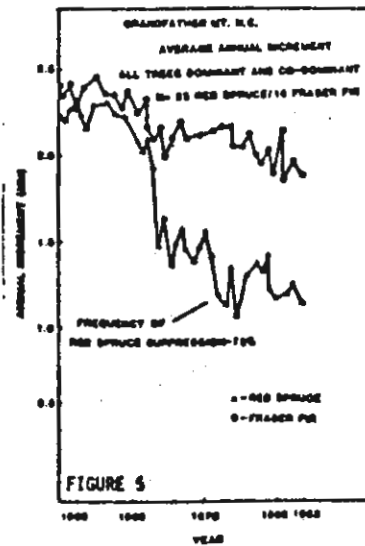
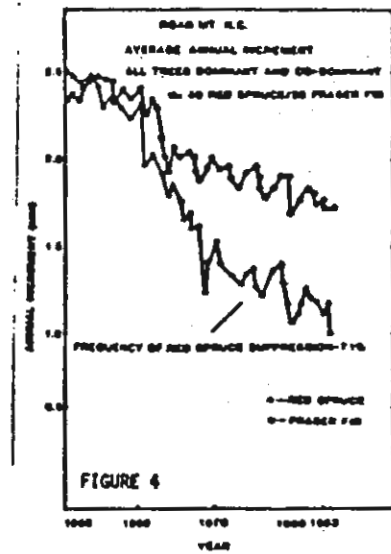
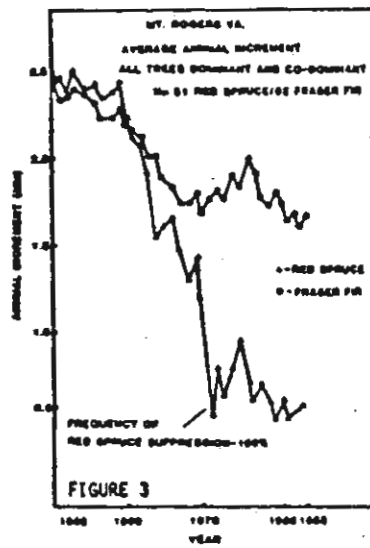
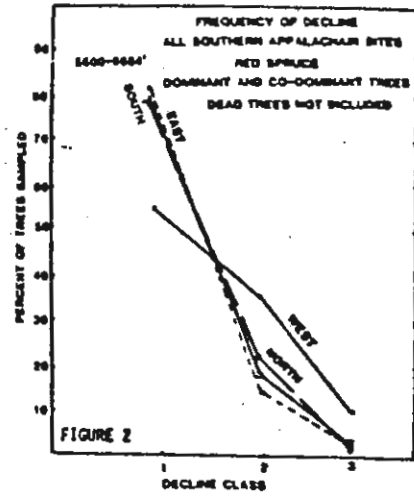
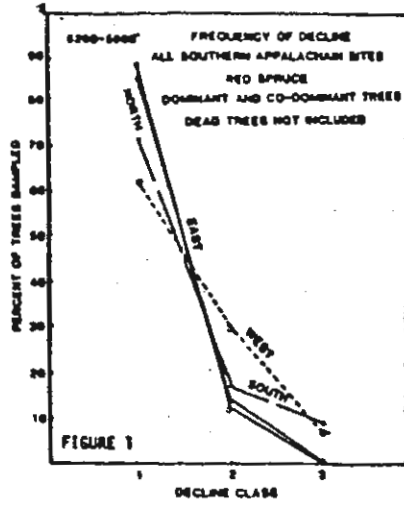
Lead concentrations in excess of 2 grams per square meter were commonly observed in forest litter at elevations above 6,000 feet. Lower elevations (5,000-5,500 feet) showed considerably less lead loading. It was also found that western-facing slopes (predominant

wind direction) had higher lead content than east, south, and north-facing slopes. The high altitude soil and litter lead contents are greater than those found in similar samples in the mountains of the northeastern United States. Unusually large amounts of Cu, Ni, Zn, and Mn were also detected on Mt. Mitchell, all in amounts greater than those observed from northeastern mountain litter samples, and in amounts that far exceed those for low elevation forests in North Carolina. The possibility that lead and copper toxicity to plants may exist on Mt. Mitchell must be investigated.

#### SUMMARY REMARKS

Our observations, which suggest that major climatic perturbation (drought, abnormal high or low temperatures) is not of significance in the southern Appalachian Mountains, strengthen the hypothesis that atmospheric deposition may contribute or be causal in the etiology of red spruce decline. Some of the possible mechanisms that need to be investigated include:

1. Hydrogen ion deposition inducing aluminum leaching, resulting in root toxicity and tree decline.
2. Calcium depletion from the soil matrix causing deficiency.
3. Nitrogen deposition (averaging about 40 pounds per acre per year causing nitrogen toxicity, i.e. death of ectomycorrhizae), uptake of excess N resulting in abnormally succulent crowns and shoots, thus decreasing the resistance of red spruce to frost, wind desiccation, and fungal or insect parasites.
4. Effects of the abnormally high concentrations of heavy metals in organic matter and soils on the vigor of roots and hence the vitality of red spruce.



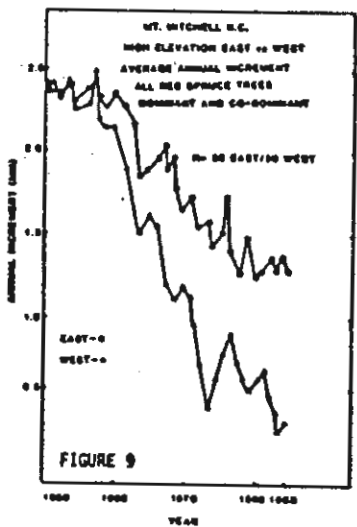
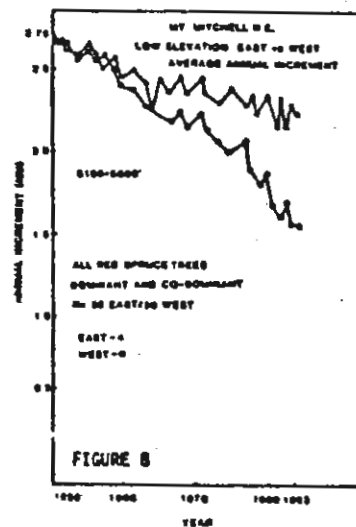
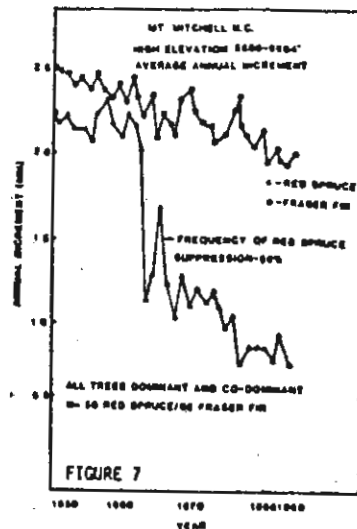
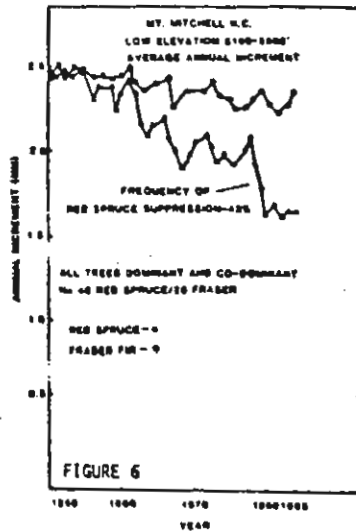


Table 1. Mass per unit area ( $\text{mg}/\text{meter}^2$ ) of Cu, Pb and Zn as a function of aspect and depth for the high elevation sites on Mt. Mitchell, NC. Values shown are the mean of three observations. Numbers in parentheses are standard errors of the means.<sup>a</sup>

Depth	ASPECT					
	West			East		
	Cu	Pb	Zn	Cu	Pb	Zn
0-2	42(3)	209(76)	152(42)	36(12)	151(39)	102(30)
2-4	21(4)	107(16)	78(12)	36(15)	124(35)	78(22)
4-6	83(31)	267(110)	208(76)	45(13)	161(24)	98(7)
6-8	100(26)	257(70)	229(68)	73(29)	199(47)	132(24)
8-10	148(9)	253(40)	289(46)	94(23)	293(103)	202(32)

Depth	ASPECT					
	North			South		
	Cu	Pb	Zn	Cu	Pb	Zn
0-2	22(6)	145(22)	83(6)	23(4)	139(42)	113(19)
2-4	26(13)	151(37)	84(22)	26(1)	178(61)	87(20)
4-6	43(23)	146(37)	115(43)	45(11)	218(33)	133(15)
6-8	51(19)	162(38)	123(39)	57(21)	184(10)	157(29)
8-10	59(20)	170(44)	134(43)	55(26)	116(23)	128(32)

<sup>a</sup>Analyses performed using the procedure of Friedland et al. (1984).

FOREST DECLINE IN THE FEDERAL REPUBLIC OF GERMANY: HOW DOES IT RELATE TO FOREST PATHOLOGY IN WESTERN NORTH AMERICA?

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Dr. Robert Bruck presented a large amount of information concerning forest decline ("Waldsterben") in the Federal Republic of Germany. Based on my year of experience in Germany in 1983, I would like to emphasize parts of the forest decline problem which relate to previous and current experiences of forest pathologists in western North America. There is reason to believe that ozone is a significant factor in causing forest decline in many parts of Germany.

Atmospheric deposition, not ozone, has received most of the attention from scientists and the press for causing the decline of the forests. This is not surprising because of the high amounts of atmospheric deposition which occur in parts of Germany, particularly the Solling Forest in northern Germany (rainwater filtered through the crowns of Norway spruce has a pH=3.4, H<sup>+</sup> deposition of 3.09 kg/ha, SO<sub>4</sub> deposition of 89 kg/ha). However, atmospheric deposition is much less extreme in Bavaria in southern Germany (rainwater filtered through crowns of Norway spruce has a pH=3.8 - 4.7, H<sup>+</sup> deposition of 0.11 - 1.37 kg/ha, SO<sub>4</sub> deposition of 33 - 57 kg/ha), but in this region a larger percentage of the trees are affected by forest decline (46-49% vs. 11-35% in the northern Germany). Atmospheric deposition is present in Germany, but it is not always correlated with increasing severity of forest decline.

Sulfur dioxide occurs in high concentrations in Bavaria and is associated with increasing severity of forest decline (Fig. 1 and 2). However, some forest decline occurs in areas where sulfur dioxide concentrations are below damaging levels (e.g. much of southern Bavaria).

Ozone measurements at two stations in southern Germany have monthly averages (April-September) of 0.04-0.07 ppm and peak hourly averages up to 0.18 ppm. These concentrations are comparable to ozone concentrations in the Sierra Nevada in California (excluding the Los Angeles region) where ozone can cause damage to needles of ponderosa pine. However, classic symptoms of ozone damage do not occur on trees in southern Germany. This does not exclude the possibility that chronic levels of damage are occurring on these trees due to high concentrations of ozone. Knowledge gained during the past 20 years on ozone damage to conifers in California could be useful in helping to ascertain the importance of ozone in causing the decline of forest trees in Germany.

Based on Dr. Bruck's presentation, three other points should be clarified. First, little mortality has been associated with forest decline. The survey in Bavaria indicated that 0.4% of the trees had died in 1983. Second, though forest decline symptoms can occur on all age classes of trees, the Bavarian survey showed that symptoms occurred on 10% of trees 1-20 years old, but symptoms were on over 60% of the trees older than 60 years. Third, chlorosis of needles occurs on conifers at the higher altitudes of mountains, but is rarely seen at lower altitudes.

Figure 1. Percent of trees with decline symptoms for the 20 forest districts in Bavaria (from the Bavarian State Forestry Department, Munich).

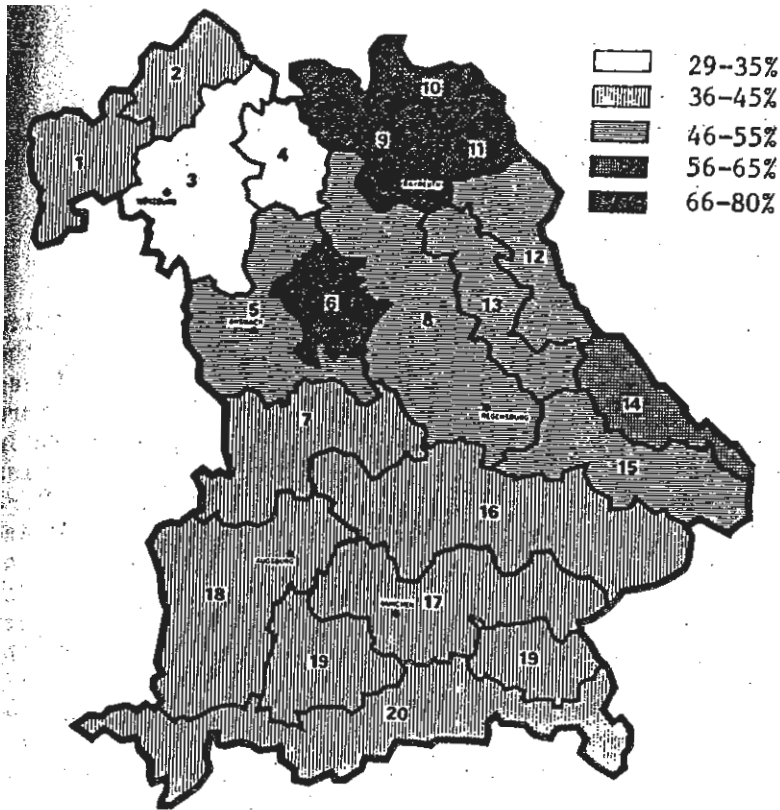
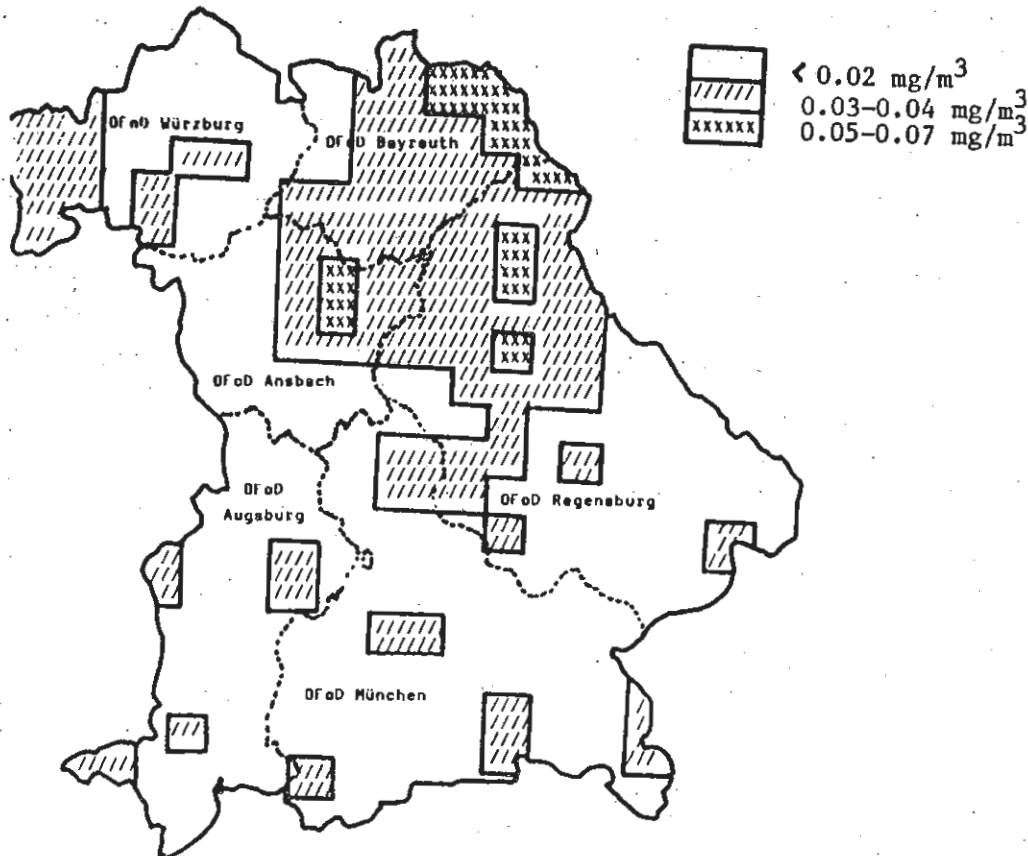


Figure 2. Yearly averages for SO<sub>2</sub> concentrations (1980-81) in Bavaria (from the Federal Ministry for Nutrition, Agriculture, and Forestry, Münster-Hiltrup).



## CURRENT PESTICIDE APPLICATION TECHNIQUES

John W. Barry<sup>1</sup>

### INTRODUCTION

The purpose of this presentation is to review pesticide application techniques and to mention a few relatively recent developments. Forest pathologists often are involved with the use of pesticides. They may supervise or manage pest management activities, be detailed to a control project involving pesticides, or be associated with the use of fungicides for seed treatment, and for control of diseases in greenhouses, nurseries, and plantations. We are reminded that the objective of any pesticide application is to achieve acceptable control and to use the pesticide safely, efficiently, and economically. This dictates that we use up-to-date techniques, calibrate and use the equipment as it was designed, and have an understanding of how and where the spray drops or dust particles deposit on target.

### DISCUSSION

Modeling Spray Behavior. The USDA Forest Service has sponsored the development of two models which predict the dispersion, deposition, and drift of pesticides. The input to both models includes drop spectrum, meteorology, and description of the pesticide tank mix and spray system. The AGDISP model provides a footprint of the spray deposition in a plane normal to the aircraft's flight path while the FSCBG model provides

information on canopy penetration of the spray and quantitates the spray drifting downwind. These models are useful to land managers in planning spray operations and in preparing EA's, EIS's, and risk assessments. Both models are on-line at the USDA Ft. Collins Computer Center (FCCC) and at University of California, Davis. Ms Patti Kenney, Forest Pest Management, Davis, CA is the systems manager for the FSCBG and Bob Ekblad, USDA Forest Service, Missoula Equipment Development Center is the systems manager for the AGDISP. Questions or assistance in running these models should be directed to Patti and Bob respectively.

Equipment. To maximize effectiveness of the spray equipment, it should be clean and in proper working order. Calibration is very important. To conform with the pesticide label application rates must not exceed those stated on the label. Calibration of equipment insures that the system is capable of delivering the proper rate.

Ultra Low Volume (ULV). ULV usually refers to application of concentrated pesticides at less than one gallon per acre. Often the material is applied undiluted at only a few ounces per acre. Effective control is achieved by atomizing drops in the effective size range. ULV is being used with more frequency. ULV is less costly and more efficient than low or high volume applications for insect control.

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Drop Size. Properly atomized, ULV applications (i.e. 24 oz/A) can deliver more drops to the target than LV applications (128 oz/A). This is achieved by narrowing the droplet size spectrum, that is by reducing the very large and very small drops. By reducing the number of large drops which are wasted we can increase significantly the number of small, i.e. one 400  $\mu\text{m}$  drop can yield eight thousand 20  $\mu\text{m}$  drops. Rotary (Beecomist<sup>R</sup>) and spinning disk (Herbi<sup>R</sup>) type atomizers offer the best opportunity to achieve fine atomization.

#### DEPOSITION

In pursuit of drop size and deposition questions we examined coniferous foliage for presence of pesticide drops from seven aerial spray projects conducted by the Forest Service from 1971 to 1981. Results were surprisingly consistent from project to project, even though formulations and application methods differed among projects. Results of our observations are summarized as follows:

1. The majority of pesticide drops observed on coniferous

foliage were less than 60  $\mu\text{m}$  in diameter, (Barry et al. 1977; Barry and Ekblad 1978; and Barry 1984).

2. Number of pesticide drops observed on coniferous needles collected from lower crown by tree species are shown in table.

3. Number of pesticide drops impacting on coniferous foliage is related to several factors:

a. Drop size. The smaller the volume median diameter of the spray, the more drops available for deposition.

b. Foliage density. Densely foliated trees, such as Ocala sand pine, collect fewer drops per needle than sparsely foliated species such as ponderosa pine and slash pine (Barry et al. 1984).

c. Location on tree. A larger number of drops are observed in the upper crown compared to the lower crown of pines (Barry et al. 1984).

d. Spray volume. As expected, higher spray volumes, i.e. 5 GPA vs 1 GPA, result in more drops on foliage than lower spray volume.

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<u>Species</u>	<u>Foliage density</u>	<u>Tank mix<sup>1</sup> application per acre</u>	<u>Drops/cm of needle length</u>	<u>References</u>
Ponderosa pine	open	1 GPA	1.05	unpublished <sup>2</sup>
Douglas-fir	dense	1 GPA	0.40	Barry (1984)
Slash pine	open	5 GPA	7.05	Barry et al. (1981)
Ocala sand pine	dense	5 GPA	0.75	Barry et al. (1981)

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<sup>1</sup> VMD of spray approximately 350  $\mu\text{m}$  for all applications.

<sup>2</sup> Data from USDA Forest Service, Southwestern Region, pandora moth control project, Jacob Lake, AZ, 1981.

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e. Application. Results (Barry et al. 1981) suggest that foliage in the upper crown, which intercepts the spray aircraft's wake, captures more drops than foliage outside the wake.

4. The majority of drops which penetrate the canopy and deposit on the forest floor beneath trees are below 100  $\mu\text{m}$  in diameter. The larger drops are observed on samples from open areas where the drops have not been screened by foliage (Barry et al. 1982).

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#### Expanded Scope of Research and Service at the Center for Forest Mycology Research

Harold H. Burdsall, Jr.

Since the research work unit now known as the Center for Forest Mycology Research was originally established as the Division of Forest Pathology of the USDA, it has changed names and locations several times. However, the research and service emphasis has remained the same, i.e. the taxonomy of the wood decay fungi and cultural identifications of same. Work on other forest fungi (e.g. mycorrhizal fungi, needle casts, rusts, etc.) was usually considered to be beyond the scope of CFMR's duties.

Today, with the increased interest in mycorrhizal associations, stains of lumber and leaf and needle inhabitants, there is a greater need for mycological assistance for forest pathologists by the CFMR in the groups causing these concerns. In order to respond to the need for research and service identifications in the Deuteromycotina and Ascomycotina as well as the Basidiomycotina as well as the Basidiomycotina, the CFMR is attempting to broaden the scope of its work to include these groups. Because of funding restrictions, the present staff will attempt to work on these problems selectively while carrying on somewhat less of the work on decay fungi.

The unit hopes to be able to provide mycological expertise to forest pathology researchers when needed and help resolve taxonomic problems in the additional groups.

In addition, the CFMR is embarking on a program to modernize both the culture maintenance and data storage and retrieval by installing liquid nitrogen, distilled  $\text{H}_2\text{O}$ , and mineral oil storage and using a new computer for culture and herbarium data and culture identifications.

We hope that these changes will more efficiently serve the forest pathologist and products pathologists in the future.

RESPONSE OF DOUGLAS-FIR TO THE FUMIGANT  
CHLOROPICRIN OR METHYLISOTHIOCYANATE  
AFTER TWO GROWING SEASONS

by

W. G. THIES and E. E. NELSON

INTRODUCTION

Phellinus weirii (Murr.) Gilb, cause of laminated root rot, is responsible for considerable mortality in the coniferous forests of western North America. The disease, its distribution and impact, and current research on control have been discussed previously (Hadfield et al 1977, Nelson et al 1981, Thies 1984).

Replanting P. weirii infested sites with Douglas-fir or other susceptible species continues the disease in the new stand. Although considerable research is being conducted on strategies to avoid the disease in subsequent stands, little has been reported on therapeutic treatments for live infected trees.

Trees in which the disease is sufficiently advanced to cause stain at stump height commonly have a spongy area of advanced decay or hollow in the root collar that is contiguous with advanced decay or stain in major roots. The presence of a continuous "duct" of infected wood suggested fumigation as a means of eliminating the pathogen from infected trees.

Several soil fumigants have been reported to eradicate fungi from power transmission poles (Graham and Corden 1980), from infested wood buried in soil (Bliss 1951, Godfrey 1936, Houston and Eno 1969), and from stumps (Filip and Roth 1977, Thies and Nelson 1982a).

Douglas-fir were shown to tolerate chloropicrin<sup>1/</sup> internally when eight treated trees remained alive and appeared healthy 3 years after injection

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(personal communications B. G. Goodell and G. G. Helsing, August 1982, Oregon State University, Corvallis, Oregon).

The discoveries that chloropicrin could be used to eradicate P. weirii from infested stumps and roots (Thies and Nelson 1982a) and that trees can survive injection with this fumigant suggested the possibility of therapeutic application of fumigants to Douglas-fir infected by P. weirii. In a paper presented to this conference in 1982 (Thies and Nelson 1982b) we reported on the survival of treated Douglas-fir 5 months after injection with chloropicrin or methylisothiocyanate (MIT). In this paper we report findings after 18 months (two growing seasons) and some additions to the study. We feel these results, though not statistically compared, are interesting and worthy of discussion at this conference.

MATERIALS AND METHODS

Much of the materials and methods have been abbreviated from our earlier report (Thies and Nelson 1982b).

The study area was a 45-year old stand of predominantly Douglas-fir in the Oregon Coast Ranges near Apiary, Oregon. Only dominant and codominant Douglas-fir, positioned to generally provide a clear view of the crown, were selected.

Subject trees

Candidate trees were examined nondestructively for the presence of P. weirii, tagged, measured, and classified into one of three infection classes (IC): IC-I, Infected; IC-II, Probably infected, crown symptoms and an inoculum source within 17 m but

<sup>1/</sup> This paper reports the results of research only. Mention of a pesticide does not constitute a recommendation for use by the U.S. Department of Agriculture, nor does it imply registration under The Federal Insecticide, Fungicide, and Rodenticide Act as amended. Also, mention of a commercial or proprietary product does not constitute recommendation or endorsement by the U.S. Department of Agriculture

P. weirii not found on the subject tree; IC-III, Probably noninfected, no symptoms and no identified inoculum source within 17 m of candidate tree.

Each infection class contained 45 trees separated into five groups of nine based on similarities of diameter breast high (d.b.h.), crown condition, and location. Selected trees ranged in d.b.h. from 27.4 cm to 62.2 cm. Each treatment was randomly assigned to one tree in each group.

#### Treatments

Initially, two fumigants, chloropicrin and MIT, were tested at several dosages. A third, Vorlex, was later added to the test. Both chloropicrin and Vorlex have been shown to eradicate P. weirii from infested stumps (Thies and Nelson 1982a). Vorlex is MIT (20%, v/v) and chlorinated C<sub>3</sub> hydrocarbons. At room temperature Vorlex and chloropicrin are liquids while MIT is a white crystalline solid.

#### Application

A series of equally spaced holes were drilled downward into the root collar past the center of each tree. After fumigant had been placed in the holes, they were plugged with a hemlock dowel.

MIT was applied as a solid in small polyethylene sacks while chloropicrin and Vorlex were poured into the holes.

#### Fumigant dosage

The dose for each tree was calculated as though we were treating the stump, roots and first 2.4 m of the stem. We estimated treated biomass by 2.5-cm d.b.h. classes from the following relationships: (1) Stem Biomass (to 2.4-m height):  $Y=0.0007128 + 0.0002716 X$ ; where  $Y$ =Stem volume in cubic meters,  $X$ =Basal area in square centimeters (Thies unpublished data,  $n=47$ ,  $r^2=.993$ ), with wood density assumed to be 0.44 g/cm<sup>3</sup>. (2) Stump and root biomass:  $\ln Y = -4.6961 + 2.6929 \ln X$ ; where  $Y$ =below ground biomass in kg,  $X$ =d.b.h. in cm,  $\ln$  = logarithms to the base  $e$  (Gholz et al. 1979,  $n=26$ ,  $r^2=.96$ ). We assumed that the effective dosage would vary linearly with the estimated biomass to be treated.

We interpreted earlier work (Thies and Nelson 1982a) to show that 1000 ml of either chloropicrin or Vorlex was the minimum effective volume required to eradicate P. weirii from a stump with a biomass of 156 kg, or about 10 ml of fumigant/1.5 kg of biomass. A liter of Vorlex contains about 232 g of MIT. For this study, a standard dosage (D) was 10 ml of chloropicrin, 10 ml of Vorlex or 2.3 g of MIT/1.5 kg of treated biomass. For ease of application, the dosages were rounded upward to the next quarter liter of chloropicrin or Vorlex (58 g of MIT). The dose applied to each tree was calculated on the basis of d.b.h. (for example doses see table 1). The nine treatments were defined in terms of standard dosages:

Chloropicrin - 2D, 1D, 0.5D, and 0.25D;  
MIT - 2D, 1D, 0.5D, and 0.25D;  
Check - no holes drilled or fumigants applied.

Each of the nine treatments was to be applied to five trees in each of three infection classes. Treatments were applied in March of 1982, except for the 2D treatments. One year later the crowns were evaluated. As a result of observed toxicity symptoms we decided not to apply the 2D treatments. In April 1983, trees designated for the chloropicrin-2D treatment were treated instead with chloropicrin at 0.125D, and the trees designated for the MIT-2D treatment were treated with Vorlex at 0.5D.

#### Data collection

The crown of each study tree was examined photographed and rated in mid-August 1982 and mid-September 1983. Particular note was made of obvious toxicity symptoms. Crowns were evaluated on an 11-point scale of symptom-severity (S-S) from dead (0) to vigorous (10).

In October 1983, dead trees were felled and their stumps and roots removed and cleaned. Roots were cut at regular intervals. When stain or advanced decay typical of P. weirii infection was found a 5-cm thick disk was removed, placed in a plastic bag, and stored in an unheated shed near the collection site. Attempts were made to isolate P. weirii from collected disks. To avoid potentially hazardous concentrations of fumigants

coming from the roots and stumps, workers wore appropriate protective clothing.

When wood infested by P. weirii is stored in plastic for two weeks at a moderate temperature (between 4 °C and 18 °C) the distinctive mycelium and setal hyphae of P. weirii commonly grow onto the wood surface to form a thick felt associated with areas of typical stain or advanced decay (Thies and Nelson unpublished data). After the culturing operation was completed the disk pieces were placed back in their plastic bag and stored in a shed at ambient temperature (between 4 °C and 20 °C) for 4 to 8 weeks before being examined for presence of the felt.

### RESULTS

After two growing seasons (18 months), some differences between treatments were evident. At the end of the first growing season there were no dead trees and only minor indications of toxicity (Thies and Nelson 1982b), but by the end of the second growing season 21 treated trees had died (table 2) and significant differences in health of the crowns had become evident between treatments (table 3). Of the 15 untreated trees (checks) one was dead. Of the remaining 14, seven had an S-S rating of 10 while the average S-S rating was 9.1. Of the 45 chloropicrin-treated trees 21 died; two of the remaining 24 had an S-S rating of 10, while the average S-S rating was 5.0. Of the 45 MIT-treated trees none had died, 25 had an S-S rating of 10, while the average S-S rating was 9.2.

Trees treated in March 1983 were all living in August 1983, but showed some change after only one growing season. A few trees treated with chloropicrin at 0.125D showed slight toxicity symptoms in a few crowns. Of 15 treated trees 7 had an S-S rating of 10, while the average S-S rating was 8.9. A few crowns of trees treated with Vorlex at 0.5D showed severe toxicity symptoms. Of the 15 treated trees 2 had an S-S rating of 10, and the average S-S rating was 6.3. Two treatments, Vorlex at 0.5D and MIT at 0.5D, contained the same amount of MIT but differed by the presence of a carrier in Vorlex. After two growing seasons none of

the 15 trees receiving MIT at 0.5D have died, 8 have an S-S rating of 10, while the average S-S rating was 8.9.

Isolations were made only from stump and root samples from dead trees. P. weirii was recovered from all disks from check trees and vigorous felts formed on nearly all disks. Attempts to isolate the fungus from root disks from the 21 dead trees treated with chloropicrin failed to recover the fungus from 77 percent of the sample disks, and felts did not form on any of the disks.

During collection of the disks, the odor of the fumigants, chloropicrin in particular, could be detected on disks collected from several roots 2.5 m from the stump.

### DISCUSSION

There are at least two important results of this study so far: (1) Although the fumigants are toxic, most fumigated trees are still living after two growing seasons. (2) P. weirii has been eliminated from most of the infested wood of trees evaluated thus far.

In this study and another recent study of fumigated stumps (Thies and Nelson unpublished data) we observed that unbroken stumps and roots retain a significant amount of fumigant for at least 18 months. This can pose a hazard to workers collecting samples but may increase treatment effectiveness. We anticipate that the fumigant will continue to diffuse into roots further from the stump, killing the pathogen as it goes. Thus with time, the fungus will remain in less and less of the root system. Therefore, analysis of the roots of additional trees that die should yield a decreasing proportion of disks with viable P. weirii.

Chloropicrin appears more toxic to Douglas-fir than MIT when applied at the same dosage. All treated trees that have died received chloropicrin. We can only speculate as to the relative effectiveness of the two fumigants on eliminating P. weirii. Based on our recent work with stumps, we would anticipate that MIT is

slightly less effective than chloropicrin in eliminating the pathogen after 18 months of exposure; however, if the MIT does not injure the tree it will have a longer time to act on the pathogen and may prove to be the more effective chemical.

One might interpret the lack of felt formation on disks from which the fungus can be isolated to mean that the pathogen, at that point in the root, is not vigorous enough to grow to the root surface and attack adjacent roots. If this proves to be the case, then all trees evaluated so far have been eliminated as sources of inoculum for laminated root rot.

For a given dosage of MIT, there is more adverse impact on Douglas-fir if the fumigant is delivered as Vorlex rather than as MIT. Because we did not apply the Vorlex carrier as a treatment without the MIT, we cannot rule out the possibility of a synergistic effect to the tree. But, if our primary goal is improve the health of the tree then MIT alone appears more beneficial.

The results so far from this field test suggest that host trees may be treated with a fumigant to eliminate the inoculum of a root rot pathogen without killing the host. Although this work should be regarded as preliminary, the results encourage additional research.

#### ACKNOWLEDGMENTS

Our thanks go to Mr. K. C. VanNatta of Rainier, Oregon, for research support in the form of providing study trees, equipment and personal services. We also thank NOR-AM Agricultural Products, Inc. (Naperville, Illinois) and Great Lakes Chemical Corporation (Fresno, California) for supplying fumigants, advice, and financial assistance. Our appreciation goes to Dr. R. D. Graham, Dr. M. E. Corden, and Mr. B. G. Goodell (Oregon State University, Corvallis, Oregon) for advice, to Mr. Harlan Fay for technical support, to Mr. Joe McNeil and Mr. Michael McWilliams for field assistance.

Table 1. Examples of fumigant doses applied to live trees

D.B.H. (cm)	BIO- MASS (kg)	STANDARD DOSE (D)	
		CHLOROPICRIN (l)	MIT (g)
15.0	24	.25	58
30.0	170	1.25	290
45.0	448	3.00	696
60.0	898	6.00	1392

Table 2. Number of dead study trees to mid-September 1983 by treatment and infection class

TREATMENT	INFECTION CLASS		
	I	II	III
Applied March 1982:			
Control	1 <sub>a</sub> /	0	0
Chloro. D	1	5	5
Chloro. 0.5D	3	2	3
Chloro. 0.25D	1	0	1
MIT D	0	0	0
MIT 0.5D	0	0	0
MIT 0.25D	0	0	0
Applied April 1983:			
Chloro. 0.125D	0	0	0
Vorlex 0.5D	0	0	0

a/ Number of trees out of 5 that died.

Table 3. Mean symptom-severity rating for trees surviving to mid-September 1983.

TREATMENTS	INFECTION CLASSES		
	I	II	III
Applied March 1982:			
Control	8 <sub>a</sub> /	9	10
Chloro. D	5	---	---
Chloro. 0.5D	8	3	4
Chloro. 0.25D	5	4	6
MIT D	8	9	9
MIT 0.5D	9	9	10
MIT 0.25D	10	9	10
Applied April 1983:			
Chloro. 0.125D	9	9	9
Vorlex 0.5D	8	5	6

a/ Mean rating of live crowns (maximum of 5 crowns). S-S ratings range from 0 (dead tree) to 10 (vigorous crown).

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CON'T P. 60

CONTROL OF DWARF MISTLETOE AT THE  
GRAND CANYON: RESULTS AFTER A  
THIRD OF A CENTURY

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The South Rim of the Grand Canyon has long been a popular recreational area. As early as 1933, however, the National Park Service expressed concern over dwarf-mistletoe infestations of ponderosa pine along the scenic roadways and in the campgrounds of the area. By 1945, many pole size and mature ponderosa were dying and growth of trees in all size classes was seriously affected. It was also feared that the ponderosa pine type was being replaced by the less desirable gambel oak as a result of the infestation (Lightle and Hawksworth, 1973).

Concern over the situation led to a mistletoe control project financed by the National Park Service. Technical guidance was provided by the Division of Forest Pathology and the Forest Service. The project consisted of pruning and selective tree removal. It was begun in September 1949 and treatments were repeated three times at about five year intervals. At the outset of the project it was realized that ponderosa pine dwarf-mistletoe was a natural parasite and attempts would be made to control, not eradicate it.

The goals of the control project were:

1. To perpetuate the ponderosa pine type along the intensively used scenic portions of the South Rim.
2. To have a continuous roadside area pleasing to the visitor.

Since this was the first large scale attempt to control dwarf mistletoe in a recreational forest, sample plots were established in treated areas and nearby untreated stands so the effectiveness of the project could be monitored. A detailed report on the results of the control project (as of 1970) was published

by Lightle and Hawksworth (1973) showing that the intensive silvicultural practices used were indeed effective in controlling dwarf mistletoe infestations in high value recreational areas.

Since 1950, the paired plots have been continuously monitored (all trees over 4 inches measured) although the control program was carried to its conclusion in 1966. I would like to update the progress of these plots as of 1982; 17 years after treatment ended.

#### Methods

The plot pair under discussion is referred to in the literature as the plot 1 series and consists of two 10 acre plots established in heavily infected overmature stands. Most of the trees on these plots were large (the average d.b.h. was approximately 14.0) and the number of trees over 4 inches per acre was 21 and 29 for the treated and untreated plots, respectively.

Criteria for tree pruning or removal on the treated plot was:

1. Remove if more than 40% of the live crown was infected or if the tree was closely surrounded by heavily infected trees.
2. Prune if lightly infected and relatively isolated.

#### Results and Discussion

Table 1 is an overall summary of stand conditions on the treated plot in 1982. The percent of infected trees has decreased and even on the basis of the original trees that were not removed by treatment, the DMR has essentially not changed from what it was in 1966 after the final treatment. Clearly mistletoe has been brought under control on the treated plot. After 1966 basal area has also steadily increased due to diameter increment of the residual trees and to ingrowth. There was no significant natural mortality and (.5 trees/acre died from 1950-1982).

On the control plot the stand DMR and percent of infected trees has increased if

ingrowth of the smaller trees is not counted. The number of larger trees per acre has also declined (Table 1). Mortality from dwarf mistletoe of larger trees has been occurring steadily throughout the measurement time. An average of 8 trees/acre died from 1950-1982. These larger trees could pose the most threat as hazard trees, necessitate the most removal effort and also be most desirable to preserve from an aesthetic point of view.

One of the goals of the control program was to perpetuate the ponderosa pine type so the condition of the reproduction must be considered. Data on the treated and untreated plots show that regeneration is good on both plots averaging 468 and 396 trees/acre, respectively. However, 25% of the young trees on the untreated plot are already infected with mistletoe.

#### Conclusion

From the data presented we may conclude that silvicultural control, through pruning and selective removal, is an effective means of controlling dwarf mistletoe on high high value recreational sites, even those that are heavily infected. Not only does treatment remove potential hazard trees, it also provides for a healthy, aesthetically pleasing stand in the future.

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Table 1. Comparison, on a per acre basis, of treated vs. untreated dwarf mistletoe infected plots in Grand Canyon National Park.

PLOT DESCRIPTION	TREES		AVERAGE STAND DMR <sup>b</sup>
	TOTAL (NO.)	HEALTHY (%)	
<b>TREATED</b>			
1950	20.7	22	2.8
1982	90.7 (8.4) <sup>a</sup>	99 (98)	.02 (.1)
DIFFERENCE	+70.0	+77	-2.8
<b>UNTREATED</b>			
1950	29.0	23	2.7
1982	85.0 (19.2)	53 (20)	1.5 (3.6)
DIFFERENCE	+56.0 (-9.8)	+30 (-3)	-1.2 (+.9)

<sup>a</sup> Numbers in parenthesis = trees over 4 inches DBH in 1982.

<sup>b</sup> DMR is based on a progressive scale of 0-6, with 0 denoting an uninfected stand and 6 denoting a stand that is very heavily infected with mistletoe.

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RISK RATING LODGEPOLE PINE  
STANDS FOR COMANDRA BLISTER RUST

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Comandra blister rust induced by Cronartium comandrae is a disease occurring on lodgepole and ponderosa pines. It is the second most damaging disease of lodgepole pine in the Rocky Mountain Region, with dwarf-mistletoe being the first. Colorado State University established as one of its long-term objectives to develop hazard rating methods for comandra blister rust in lodgepole pine stands of the Rocky Mountain Region.

The work reported in this paper deals with an initial study related to the hazard rating objective. The major objective of this study was to determine the relationships between the distribution and biology of the rust, comandra stand characteristics and rust incidence in pine stands. In order to look at these relationships the following research has been carried out or is planned:

1. Locate and map comandra (Comandra umbellata) populations near lodgepole pine stands.
2. Ascertain the presence of rust on comandra and pine hosts.
3. Relate rust incidence to distance between comandra and lodgepole pine stands.
4. Relate major topographic features to rust incidence in pine host.
5. Relate stand characteristics to rust incidence in pine host.
6. Monitor weather during basidiospore dispersal period.
7. Identify past episodes of favorable weather.

The results obtained to this point are preliminary and concern only the Wind River District of the Shoshone National Forest.

During the summer of 1983, 143 possible comandra sites were visited. This represented approximately 15,375 acres of rangeland adjacent to or located within forested areas. Of these, 76 sites were found to contain comandra populations. From this sample, comandra was found to commonly inhabit dry, more open, southwest facing sites, predominantly on the middle to upper slopes and ridgetops. Sagebrush was the dominant vegetation associated with comandra plants on 59% of the sites. Comandra populations were rare on sites where grasses were dominant.

In the summer of 1984, 33% of the sites containing comandra were revisited. This was to ascertain and quantify the presence of rust on comandra hosts. This study showed that rust was present on all sites, but at varying intensities.

Three semi-permanent plots at three elevations were set up to follow rust intensification in comandra over a season. The first readings were taken in mid-July, and the final readings in mid-August. The low elevation site went from low to high rust intensity. The mid-elevation site went from very low to low intensity and the high elevation site went from zero to very low intensity. No solid conclusions can be drawn from this study at this time because of the small sample size.

Rust incidence data were taken in lodgepole pine stands located at various distances from comandra populations. Most of the sampled stands had a rust incidence between 11%-50%. The stands farthest from comandra plant sites were approximately six miles away. The data will be analyzed to see if there are any distance-to-incidence relationships.

## Oleoresin Exudation Pressure in Ponderosa Pine

### Infected with Armillaria mellea

Andrea L. Koonce and Lewis F. Roth

The association between bark beetles and root rots in conifers is well documented (Bega, et al. 1966, Caird 1935, Cobb, et al. 1968, 1974, Erlich 1939, Partridge and Miller 1972, Stark and Cobb 1969, Stark et al. 1966, Thomas and Wright 1961).

Conifer susceptibility to bark beetles is believed to be related to a decline in tree vigor as evidenced by foliar appearance. Keen (1936, 1942) and others (Salman and Bومberg 1942, Vite and Rudinsky 1962b) have indicated that crown forms characteristic of tree growth and vigor may be used to indicate tree susceptibility to bark beetles. The appearance of foliage and crown morphology alone was used reliably by Keen to predict beetle attack. This is particularly relevant since the poor (beetle susceptible) rankings are associated with trees infected with root rot and such a method is used in recognizing and reducing Armillaria mellea (sensu lato) in thinning cuts (Roth 1969). Trees declining from photo-oxidant injury and needle scorch are also attacked more frequently than healthy trees by bark beetles (Compton et al. 1961, Stark, et al. 1967) reinforcing the association between tree decline and bark beetles.

Vite and Wood (1961) relate the susceptibility of ponderosa pine to bark beetle attack to the oleoresin exudation pressure (o.e.p.) of the tree. Trees with low resin pressure, less than 4 atm., support mass attraction of beetles because they can be successfully colonized. Stressed trees appear to lack an effective resinosis response, e.g. a rapid, abundant resin flow which is slow to crystallize (Cobb, et al. 1967).

Resin exudation is also known to affect tree susceptibility to fungal pathogens (Bega and Terry 1968, Cobb et al. 1967, Shaw 1974). Resin added to agar media has been found to stimulate Armillaria growth in the field, however, resin saturated roots are sealed from acropetal invasion of the fungus (Shaw 1974).

In Southcentral Washington, Armillaria root rot advance can be described as waves of progressive mortality, generally originating from an old growth stump. Shaw (1974) showed root rot in this area to slowly increase frequency of infection on tree roots located on the interface of an infection center. The tree responds by occluding infected roots with resin, and thus decreases its functional root area as well. The "quiescent" phase at the interface of the infection center is assumed to be a period where root colonization is insufficiently stressful to cause noticeable crown decline. The above ground evidence of root rot advance in the quiescent phase is a series of old, small stubs, broken snags, and dead trees. In "active" centers, dying and declining trees are recognized by the appearance of their crowns which is often strikingly chlorotic and thin.

Bark beetle behavior is a result of interaction with the tree. Beetles disperse at random, and are attracted to individual trees in flight by sensing the tree's volatile compounds (Rudinsky 1966). Weakened trees have the greatest likelihood of attracting and succumbing to both endemic and epidemic beetle attacks (Vite and Wood 1961). The attraction is based on tree volatiles and the mortality results because of inability of the tree to occlude attack.

Flow and pressure through the resin canals of a tree follow diurnal and seasonal patterns, and are directly related to water relations in a tree (Vite 1961). Oleoresin exudation pressure is highest in the pre-dawn hours when cell turgor is also high. It then falls to a low point in the afternoon as the tree transpires, and recovers in the evening as water loss is replenished and transpiration is reduced (Vite 1961). Different species have characteristic resin composition and behavior (Hanover 1975), and resin pressure may vary among trees of the same species and vigor (Rudinsky 1966).

The purpose of this study was:

1. To quantify threshold values of O.E.P. in relation to decline in trees infected with root rot in active and quiescent infection centers
2. To correlate resin behavior with crown appearance,
3. And to correlate o.e.p. with beetle attack in declining trees.

#### Methods

The study area was located in the Glenwood management block of the St. Regis Paper Company, Klickitat County, Southcentral Washington at an elevation of 975 m. Annual precipitation is 60 cm falling primarily as snow. During the growing season temperatures range from 1-30°C with average mid-day temperatures of 22°C. The soil was derived from fine dacite pumice and has little profile development. The vegetation represents a fire climax in ponderosa pine-bunchgrass (Franklin and Dyrness 1973). The timber was moderately dense pine, approximately 50 years old, that established on overgrazed land and developed under large, scattered old growth.

The Glenwood block has many large, sometimes coalescing root rot infection centers where study trees were located. Thirty-five trees, averaging 30 cm d.b.h., were selected around the interfaces of 1 quiescent and 2 active root rot centers. When possible, trees were paired - one closer to the interface, with a poor or symptomatic crown condition and one beyond the interface which was less symptomatic. In the quiescent center the trees were selected without intentional pairing.

Resin pressure was measured by threading 200 psi hydrostatic pressure gauges filled with turpentine to each tree. The turpentine was required to prevent resin crystallization inside the gauges. Resin pressure was sampled 5 to 7 times from dawn until dusk the following day. Resin flow gauges were also constructed from glass tubing, however, clogging of these gauges could not be prevented. Consequently, the quantity of resin flow and crystallization were judged on their appearance in the reservoir left after removing the hydrostatic gauge. Three sampling periods were selected in the summers of 1976 and 1977, and were observed informally in 1978. Crown color, needle length and retention, mortality, and symptoms of bark beetle attack were recorded during each observation period.

Root rot infection was assumed for all trees in the study based on the tree's proximity to the visibly advancing front. Root rot severity was estimated by o.e.p. values, and the visual appearance of the crown - its color and vigor. Evidence of bark beetles included the presence of beetle galleries and frass, or the beetles themselves.

## Results

The active infection center interfaces were not significantly different ( $P=0.95$ ) than the quiescent center in their characteristics of decline, so data from all 3 centers were combined.

The range of o.e.p. minimum and maximum values was from 0 to 10.1 atm. (Table 1) The most vigorous trees had high early morning resin pressure averaging 9.1 atm. (Fig. 1) The pressure dropped gradually to a low point of approximately 3 atm. in mid-afternoon, and recovered quickly to nearly maximum pressure in the early evening. When the resin gauges were removed the sap would flow down the bark from the full reservoir and gauge.

Table 1 Average values for oleoresin exudation pressures in trees within and among three root rot interface areas.

Location	Stress class:	Average o.e.p.'s (atm)			
		Area I (Active)	Area II (Quiescent)	Area III (Active)	Combined
Dying (n=8)	Min.	0 <sup>a</sup>	0	0	0
	Max.	0.3	1.7	0.5	0.5
Declining (n=15)	Min.	1.4	1.7	1.2	1.4
	Max.	7.2	6.3	7.0	6.8
Vigorous (n=12)	Min.	3.7	2.0	2.6	3.0
	Max.	9.6	9.0	0.8	9.1

<sup>a</sup>Averages are of readings on 3 sampling dates, maximums were at dawn, minimums at mid-afternoon

A somewhat larger group of trees had noticeably declining o.e.p.'s when compared to the trees described above. The maximum o.e.p.'s varied widely but seldom reached 7 atm. The mid-day minimum o.e.p.'s were always below 2 atm. The recovery in the evenings was slow to begin and was sometimes inaccurately recorded due to crystallization in the gauges. The general daily o.e.p. behavior curve is seen as a weak shadow to the vigorous trees. Resin quantity varied widely. Rapid crystallization was common

and resin flow was a trickle at best.

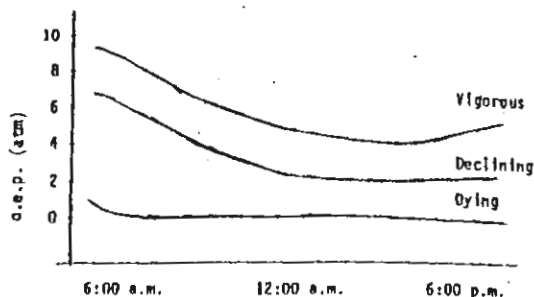


Figure 1. Distribution of average daily oleoresin exudation pressures for trees in 3 stages of decline at the interface of *Armillaria* root rot infection centers.

O.e.p. was generally 0 if the tree crown was markedly symptomatic. Six trees whose pressure fluctuated around 2 atm. or less declined rapidly and died the same season. Two trees with average pressures of 4 atm. died within a year. Dying trees and those rapidly declining rarely had observable resin in the reservoir once the gauge was removed.

The difference in severity of decline as measured by o.e.p. was significant in 65% of the paired trees. In these trees the pair partner proximal to the interface of recognizable mortality had o.e.p. values which were consistently lower than the tree located more closely to the vigorous stand. (Fig. 2) Pairs whose trees were located in very close proximity to each other (within several feet) had essentially the same o.e.p. behavior. Trees which were located around the infection center at approximately the same distance from the advancing front were also comparable in decline as reflected in their resin characteristics.

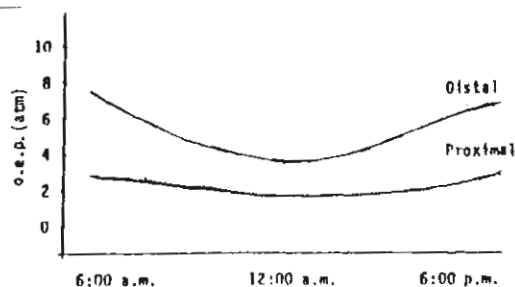


Figure 2. Oleoresin exudation pressure of distal and proximal trees respectively at the interface of an *Armillaria* root rot infection center.

Crown appearance could not be reliably correlated with the stages of decline indicated by o.e.p., generally, estimates of decline based on appearance overestimated tree vigor indicated by resin pressure. Trees with still green crowns, although chlorotic and thin, were assumed to be alive although only one such tree had measurable resin pressure. The greatest degree of variability was in the declining trees. The range of crown vigor was wide and at least 1/3 of the trees with declining o.e.p.'s still had full, dark green needles. One vigorous tree, on the other hand, had an unusually heavy annual needle loss.

Trees were not attacked by bark beetles until the o.e.p. dropped below 1 atm. Eighty-eight percent of the dying trees had evidence of beetles. One tree which had had just under 1 atm pressure was attacked the day following sampling, and o.e.p. had dropped to zero when checked.

#### Discussion

The results indicate a decline in o.e.p. from the vigorous stand toward the interface of active mortality. Resin pressure can be a more sensitive tool to monitor stages of declines than visual appearance alone. But it is not sensitive enough to distinguish between trees in close proximity to each other. Visual decline symptoms are reliable only for advanced stages of decline and ocular estimates of tree decline tend to underestimate severity. Thinning and spacing procedures for root rot control which are based on selecting vigorous appearing trees should emphasize caution in identifying healthy trees. Questionable or borderline trees could be sampled for o.e.p. and trees with minimum o.e.p.'s of less than 4 atm. could be cut first. Critical o.e.p. for attracting bark beetles in this study was 1 atm. However, since many of the trees dropped below the threshold level reported by Vite for sustaining mass attack it is

likely that trees in interface areas would be quite vulnerable during times of epidemic beetle outbreaks.

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FACTORS CONTRIBUTING TO A SEVERE  
ROOT-AERIAL DISEASE COMPLEX AT A LARGE  
CONIFER NURSERY.

Robert V. Bega

The Forest Service Humboldt Nursery on the north coast of California has a long history of disease problems dating back to the late 1960's and early 1970's. Historically, species of *Sirococcus* and *Phoma* have been reported as the most consistently isolated and most damaging agents. The conifer species most affected are Douglas fir (*Pseudotsuga menziesii* (Mirb.) Franco), red fir (*Abies magnifica* A. Murr.), white fir (*A. concolor* (Gord. & Glend.) Lindl. ex Hildebr.), Ponderosa pine (*P. ponderosa* Dougl. ex Laws.), and Jeffrey pine (*P. jeffreyi* Grev. & Balf.).

In the 1981-82 season alone the nursery lost 90% of its red fir crop (498 thousand seedlings), 20% of its Douglas fir crop (2.7 million seedlings), and 41% of its ponderosa and Jeffrey pine crop (60 thousand seedlings)<sup>(3)</sup>. The true fir and Douglas fir mortality and cull was attributed primarily to *Phoma eupyrena* Sacc. and the ponderosa-Jeffrey losses to *Sirococcus strobilinus* Preuss, and to a lesser extent *Phoma* spp.

Over the past 14 years several fungicides have been tested to determine their efficacy in controlling the top blight complex. There have been numerous promising results and numerous failures. As a result, of one series of tests by Smith, et al.<sup>(5)</sup> for control of *Sirococcus* on ponderosa and Jeffrey pines, chlorothalonil, captafol and mancozeb were efficacious. Thereafter, most beds in the production nursery were routinely sprayed with chlorothalonil from 1975 through 1980. In 1981, however, chlorothalonil was detected by the North Coast Water Resources Board in a tributary creek flowing near the nursery. Nursery personnel suspended the use of the material in the 1981-82 season. Subsequently losses in Douglas

fir and pines again increased and red fir, previously lightly affected, was completely wiped out. The red fir top blight was identified as *Phoma eupyrena*<sup>(2), (3), (4)</sup>. None of the fungicides tested in 1982-83 effectively controlled the "Phoma Blight" of red fir. This was thought to be due in part, however, to an abnormally wet winter when no spraying was done for eight weeks of January and February. Soil core formation, especially on red fir is thought to be a contributing factor.

#### MATERIALS AND METHODS

In March of 1984 soil and diseased seedlings of 1-0 Douglas fir were received from the nursery with a request for diagnosis. The seedlings were stunted, somewhat chlorotic, with a severely restricted root system and numerous rootlet lesions. Some stem and needle lesions were also evident.

Several methods of isolation were attempted: 1) routine plating out of sections of rootlets, hypocotyl (soil line), and stem-needle on; a) barley straw agar; b) V-8 antibiotic agar. 2) 3-1 soil slurry baited with surface sterilized lemon at 5°, 10°, 15°, 20°C, and room temperature under lights, then plated out on a and b; 3) alfalfa seeds sown into moist soil at room temperature, and the resulting seedlings plated on a and b. All tissues except those from lemon were surface sterilized in 0.525% sodium hypochlorite before plating. Organisms growing out from the various tissue sections were immediately hyphal tipped onto PDA slants and identified to genus or species based on spore characteristics. Pycnidial forming fungi were also identified directly on the straw agar plates.

#### RESULTS

The most consistently isolated organisms from all methods tested were *Fusarium oxysporum*, a species of *Pythium*, and *Phoma* spp. Lemon and

alfalfa effectively trapped *Pythium* and *Fusarium* from the soil and occasionally *Phoma*. In the lemon-soil slurry trapping technique, 10°C was the most efficient, *Phoma* and *Fusarium* were occasionally isolated at 15° and 20° C.

As expected, straw agar was effective in isolating all pathogens from the three types of seedling tissues, but also yielded numerous saprophytic organisms. V-8 antibiotic agar was selective for *Pythium*, but with time also allowed *Fusarium* to grow out.

Cumulative isolation percentages on all techniques for the 3 pathogens were: 1) Rootlets - *F. oxysporum* 94%, *Pythium* spp. 81%; 2) hypocotyl (soil-line) *F. oxysporum* 100%, *Pythium* spp. 6%, *Phoma* spp. 6%; 3) stem- needle-- *Phoma* spp. 25%, *F. oxysporum* 81%, *Pythium* spp. 6%.

#### DISCUSSION

These preliminary isolation techniques are leading to ongoing, more quantitative isolations and future research on a root-aerial complex approach to the top blight problem existing at the Forest Service Humboldt Nursery. The thesis being followed is to determine whether edaphic factors such as soil borne pathogens, soil structure, nursery management approaches, and even pesticide usage are predisposing agents for the top blight problems or if all are involved cumulatively. Even El niño is being considered.

Isolations from stored and out-planted seedlings of Humboldt Nursery origin received from the Siskyou N.F. in 1984 had the same number and percentages of pathogens as isolated directly from the nursery.

Research underway by Hamm and Hansen<sup>(1)</sup> at Oregon State University are showing the same results in a top blight problem at several northwest forest nurseries.

Current studies underway by the author on Douglas fir and western white pine seedlings from the J. Herbert Stone Nursery in Oregon are showing the same preponderance of organisms as the Humboldt Nursery.

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POTENTIAL OF TRICHODERMA FOR BIOLOGICAL  
CONTROL OF LAMINATED ROOT ROT

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Phellinus weirii (Murr.) Gilb. causes laminated root rot, a serious disease of conifers in western North America. Roots of new generations of conifers become infected when they contact infested roots remaining from a previous forest stand (Nelson et al. 1981). Control measures have focused on removal or destruction of stump and root inoculum prior to reforestation with susceptible conifers (Thies 1984).

In time, other organisms replace P. weirii in colonized roots and stumps. This invasion is delayed by zone lines formed by P. weirii, but when zone lines are absent or formed incompletely, fungi, especially Trichoderma spp., readily invade the wood and suppress or replace P. weirii (Nelson 1967). While this biological control of P. weirii occurs naturally, it is generally at a level and pace unacceptable in forests managed for the production of timber.

Biological control of wood decaying fungi is achieved when the control agent is introduced before or at the same time as the pathogen. Rishbeth (1979) applied Peniophora gigantea (Fr.) Masee to pine stumps at harvest to prevent invasion by Heterobasidion annosum (Fr.) Bref. (Fomes annosus). Species of Trichoderma prevented invasion of spruce stumps by H. annosum, at least seasonally (Kalio and Hallaksela 1979; Ricard 1977). Tree wounds were protected from invasion by wood destroying fungi when first inoculated with Trichoderma viride Pers.: Fr., with mixtures of other Trichoderma spp. (Mercer 1982), or with Trichoderma harzianum Rifai (Smith et al. 1981). Silver leaf, caused by Chondrostereum purpureum (Fr.) Pouz. can be prevented by inoculating pruning wounds with

antagonists (Grosclaude et al. 1973). Inoculum is commercially available in Europe (Cook and Baker 1983).

When the fungus is well established in stumps or root systems before an antagonist is introduced, control of wood destroying pathogens has not been consistent. Ricard (1976) controlled decay in utility poles with a species of Scytalidium or a combination of T. viride and T. polysporum, and Rishbeth (1979) had some success with P. gigantea against H. annosum in stumps.

Earlier we reported preliminary results of inoculations with three isolates of T. viride into Douglas-fir stumps infested with P. weirii (Nelson and Thies 1981). Now, results of completed work point to significant differences in success among the inoculation techniques we tested.

#### Materials and Methods

Three separate but interrelated studies were established on two harvested sites near Sweet Home, Oregon. The first measured the relative success of three isolates of T. viride and compared dowel inoculum with spore-nutrient pellets. The second measured relative success of inoculation of stumps in three decay classes. The third measured the effect of time of year on inoculation success.

For the studies we selected year-old stumps of Douglas-fir (Pseudotsuga menziesii (Mirb.) Franco) 35 to 50 cm in diameter. P. weirii was verified as the cause of stain or decay on stump surfaces by culturing wood chip samples onto malt agar. Determinations were based on colony morphology, including the presence of setal hyphae (Nelson 1975). In the first study, 29 infested stumps were stratified on the basis of surface stain and decay, and 24 of these were treated, with five serving as uninoculated controls. In the second study, nine decayed, nine stained, and nine sound stumps were inoculated. In the third study nine stumps with stained tops were inoculated in each of the three months: February, June and October. The June treatment in the third study doubled as the stained stump

treatment of the second.

Inoculum was prepared from three isolates of T. viride shown to be antagonistic toward P. weirii in culture (Nelson 1969). The isolates were collected from forest soil at 530 m elevation in the Oregon Coast Range near Philomath, Oregon. Two types of inoculum were prepared for each isolate: (1) birch dowels, 1.9 cm x 30 cm, were autoclaved in water at 1.06 Kg/cm<sup>2</sup> for 30 minutes, placed in sterile jars and four days later inoculated with one isolate per jar. Jars were incubated at room temperature (22 to 26°C) for about three months. Sterile water was added as needed; (2) pellets were prepared from barley grains separately inoculated with each of the three isolates and incubated in a rotating drum fermenter for ten days. The material was then dried, milled, formulated with diatomaceous earth, molasses and water, and extruded into pellets. The pellets were dried to two percent moisture content or less.

Stumps were prepared for inoculation by drilling three vertical holes, 1.9 cm diameter and 30 cm deep, in areas of stain or decay on the stump top. To facilitate sampling, where possible holes were a minimum of 14 cm apart and 7 cm from the wood-bark interface. Control stumps were neither drilled nor inoculated.

In the first study, 12 stumps were inoculated with pellets and 12 with dowels. Each of the three holes in pellet-inoculated stumps was filled with pellets of a different Trichoderma isolate, thoroughly wetted and plugged with a 5 cm long, uninoculated dowel. In the dowel-inoculated stumps only two dowels were used because the third set of dowels became contaminated during incubation.

For the second and third studies, similar procedures were used but only mixtures of pellets of the three isolates were used.

One year after inoculation, all stumps were sectioned at 10, 20, and 30 cm below and parallel to the stump

surface. Sections from inoculated stumps were dissected with a band saw into wedges to separate inoculation holes. Each wedge, with its inoculation hole approximately centered, was split aseptically along three lines radiating from the hole towards the pith and approximately 120° on either side. Small wood chips were taken midway between the top and bottom of each split face just outside the edge of the hole and at 2, 4, and 6 cm (where possible). Stump sections of controls were sampled by taking 12 chips at random from stained or decayed wood. Chips were placed on malt agar slants and incubated in the laboratory (20 to 26°C/intermittant illumination) for up to three weeks. Colonies were identified on gross appearance or, if colonies appeared atypical of Trichoderma spp., they were examined microscopically. No attempt was made to identify isolates by species. Wood condition (advanced decay, stain, or sound wood) was recorded for each chip.

Colonization by Trichoderma spp. around each inoculation hole was expressed as the percentage of chips from which Trichoderma spp. were isolated. Chi-square analyses were used to test differences in colonization among treatments, among stump sections (distance from stump top), among decay stages at point of chip sampling, among sampling distances from inoculation holes, and between treated and control stumps. Differences were judged significant at  $P \leq 0.05$ .

#### Results

Colonization of stumps by Trichoderma spp. did not differ significantly among the three isolates of T. viride used in the pellet inoculations or between the two isolates used in the dowel inoculations (table 1). Differences in colonization between dowels and pellets, however, were significant regardless of whether the isolate missing from dowel-inoculated stumps was included in the analyses. We also found significant differences in inoculation success among stump decay classes; sound (2%), stained (12%) and decayed (46%) (table 2); and among the times of the year stumps were

Table 1. Recovery of *Trichoderma* spp. from stumps inoculated with three isolates of *T. viride* in pellets or dowels

Distance from stump surface Centimeters	Pellets				Dowels <sup>1</sup>		
	Isolate				Isolate		
	1	2	3	Average	2	3	Average
	Percent						
0-10	59	56	56	57	37	38	37
10-20	39	32	25	32	21	19	20
20-30	23	22	16	20	18	13	16
Average	41	36	32	36	25	23	24

<sup>1</sup>Isolate 1 in dowel inoculum was contaminated and not used.

Table 2. Recovery of *Trichoderma* spp. from stumps in three decay classes inoculated with three combined isolates of *T. viride* in pellet form

Distance from stump surface Centimeters	Decay class			
	Decayed	Stained	Sound	Average
	Percent			
0-10	72	22	4	32
10-20	33	10	2	14
20-30	9	3	0	10
Average	46	12	2	19

Table 3. Recovery of *Trichoderma* spp. stumps inoculated in February, June, and October with three combined isolates of *T. viride* in pellet form

Distance from stump surface Centimeters	Month			Average
	February	June	October	
	Percent			
0-10	40	22	35	32
10-20	17	10	34	20
20-30	11	3	18	11
Average	23	12	29	21

inoculated; February (23%), June (12%) and October (29%) (table 3).

In the first study, isolation of *Trichoderma* spp. from uninoculated stumps was significantly less frequent than from treated stumps. Frequency of isolation from inoculated stumps was directly related to; (1) proximity to inoculum, (2) proximity to stump top and (3) stage of decay at points from which isolations were attempted.

#### Discussion

*Trichoderma viride* can be introduced and become established in stumps infested with *P. weirii*. Not surprisingly, establishment occurs more often near the source of inoculum, but colonization can occur up to 6 cm from the source in one year or less. The more frequent occurrence of *Trichoderma* spp. in wood in advanced stages of decay than in stained or sound wood can be explained by differences in the nutrient status of sound wood and decayed wood, lesser

resistance to movement of the fungus in decayed wood, and the ability of the antagonist to parasitize P. weirii, thereby benefiting from its presence in stained or decayed wood.

It is not surprising that inoculations were most successful in stumps with advanced decay because in all studies we isolated Trichoderma spp. more commonly from decayed wood than from stained wood and much more commonly than from sound wood.

Temperature and moisture relationships within stumps change with season, thus timing of inoculation could be important to establishment of Trichoderma spp. June, when moisture content was still relatively high and temperatures were increasing, was expected to be the month most favorable to the establishment and growth of T. viride. We have no explanation for the fact that inoculations made in February and October were more successful than those made in June.

Isolates of Trichoderma spp. vary greatly in hyperparasitic tendencies and in production of enzymes and antibiotics (Dennis and Webster 1971a, b, c). For operational control of P. weirii, significant improvement in colonization over that reported here would be needed. To be effective in biological control of P. weirii, antagonistic fungi must colonize infested major roots and displace the pathogen in 5 to 10 years. After that time conifers regenerating harvested sites will have become infected, and infected roots will be large enough to perpetuate the disease. Inoculation success may be enhanced by improved materials and methods. A high priority should be placed on discovering and testing isolates of Trichoderma spp. that are highly antagonistic to P. weirii and adapted to the stump and root

environment. We are searching for and testing new isolates for antagonism toward P. weirii and ability to grow over a range of temperatures, especially 0 to 15°C. Formulations of inoculum or stump treatments that favor antagonists may reduce the pathogen's advantage of prior possession of the substrate. The potential for selective inhibition or stimulation of organisms with chemicals clearly exists (Cook and Baker 1983). Nelson (1975) found that P. weirii in buried wood tended to be replaced by Trichoderma spp. when urea was mixed with the soil or broadcast on the soil surface. Ohr et al. (1973) demonstrated that Armillaria mellea (Vahl: Fr.) Kummer in citrus roots could be attacked and killed by Trichoderma following sub-lethal soil fumigation. Tolerance of fungistatic compounds by Trichoderma spp. suggests numerous possibilities for applying these materials to stumps along with Trichoderma spp. Changes in major nutrients, such as nitrogen or simple carbon sources might also influence establishment of antagonists in wood colonized by P. weirii.

We feel that the key to successful biological control of P. weirii is the study of microbiological activity in the stump environment. For only with better understanding can we hope to induce changes that favor the antagonist over the pathogen.

#### Acknowledgements

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We also thank Mr. Duane Weiss and Mr. Harlan Fay for assistance in field and laboratory aspects of the study.

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## Field Trips

### The Complete Guide (Sept. 21-23)

Frank Hawksworth and Bob Gilbertson started looking for Taos at Flagstaff, AZ; they succeeded, for both were at meeting. Undoubtedly they saw dwarf mistletoe and rot along the way.

### Beyond Chao Canyon (Sept. 23)

About 30 persons attended Ed Wood's phenomenal tour of Chao Canyon, and of this motly mob about 4.5 car-loads pushed on behind the bushy beard. On this trek to Taos we saw the largest living ponderosa pine in New Mexico, spectacular scenery, a hunter on horseback loaded down with horns of powder and a muzzle loader, various interesting plants, pot sherds and two diseases. These were Armillaria and dwarf mistletoe. We went for ever on a road that not all the vehicles could handle to a destination, which we did not want to reach having lost or misplaced the intended destination. Nevertheless, we saw a selective tree removal operation to eliminate the most severely infested ponderosa pines (dwarf mistletoe) which covered many km and lasted several years.

### Aspen Stalking (Sept. 27)

Tommy Hinds produced a bonanza which included droopy aspen, buboes, Ganoderma applanatum, sooty-bark canker, hypoxylon canker, Cryptosphaeria canker, Dothichiza (Sclerophoma) canker, Ceratocystis canker, Pollaccia americanum, ink spot, cork bark, Diplodia tumefaciens, Phellinus tremulae, Armillaria and vole damage, all relatively close to Taos under ideal weather conditions. A few conifer diseases were also observed including Arceuthobia, E.t.

?bacterial gall of Douglas-fir and burls. We also located the sensuous cork-bark fir and bristle-cone pine.

### Cumbres and Toltec Express (Sept. 27)

Above the ink spotted forests could be heard the good sound discussions among merry forest pathologists as the train cruised amongst the different, but stimulating forest sites. And around the bend came Ceratocystis canker, pointed out by the tender master, Jerry Beatty.

## WIFDWC BUSINESS MEETING MINUTES

The business meeting called to order by Chairman, Tom Hinds at 10:15 a.m. September 28, 1984. A summary of the major points discussed is presented below.

### REPORTS

**Minutes:** approved as printed in the proceedings for the 31st WIFDWC.  
**Treasurer's Report:** Ken Russell has investigated the possibility of investing our account to earn more interest but found that the additional hassle wouldn't be worth it. It was suggested that the new executives be added to the signature list for our account to avoid problems that might arise if something happened to Ken.

**Committee Reports:** Summaries were presented.

**Local Arrangements:** Jerry Beatty reported that 74 professionals had registered for the meeting and that number swelled to 105 including friends and spouses.

### OLD BUSINESS

**Common Disease Names** - Frank Hawksworth reported that a great many comments had been received and incorporated where appropriate. The goal is to come up with a nationwide list which could be included in the Phytopath Society official listing.

**1985 Meeting Location** - Ken Russell gave some brief details about holding the meeting in Olympia, Washington with a field trip to Mt. St. Helens. Additional discussion was postponed to "New Business" (see below).

## NEW BUSINESS

### Retirees

The following names were added to the WIFDWC list of retirees:

Mike Finnis, Larry Wier, Paul Aho, and Gardner Shaw.

**1985 Phytopathology Meeting** - Fields Cobb announced that the 1985 National APS Meeting would be held in Reno, Nevada, August 10-14 and might conflict with the 1985 WIFDWC meeting. The California pathologists will be involved in developing a field trip and that APS had appointed a subcommittee to organize a discussion session regarding forest pathology for the APS meeting.

There was considerable discussion about trying to increase our participation in such meetings and that better efforts be made to possibly coordinate future meetings.

Fields also announced that APS will sponsor a Verticicladiella symposium.

**1985 WIFDWC Meeting** - After some additional discussion a unanimous decision was made to continue with plans for the 1985 WIFDWC to be held in Olympia, Washington, rather than move it to coincide with the APS meeting.

**1985 WIFDWC Date** - The possible dates for the 1985 Work Conference were discussed at length. A motion for August 25-30 was narrowly defeated and a motion for September 23-27 carried.

**Rust Committee** - Brian Geils made a motion to officially form a Rust Committee. (The preliminary title of Stem Rust Committee was reduced to Rust Committee to include all rusts.) The motion was passed unanimously along with a motion to have Rich Hunt chair the Committee.

Costs of Proceedings - This controversial issue again raised considerable interest although the following motion carried unanimously:

From now on the proceedings will be mailed only to paid registrants and honorary members who have indicated a desire to receive it and will be made available to all others at cost.

WIFDWC Name Change - It was suggested that travel restrictions might be eased if we were to drop the word "International" from our work conference title. This again created considerable discussion and the motion was finally tabled until next year so that it could be addressed by more of the membership. The first mailing regarding the 1985 meeting will include comments regarding this suggestion.

1986 Meeting Location - Invitations to host the 1986 Work Conference were received from Hawaii, Juneau, Logan and Colorado. The clear choice was Juneau, Alaska, and Terry Shaw provided cost analysis that showed lodging would be cheaper and travel cost about equivalent to this year. Special accommodations will be available to students.

1985 Officers - In spite of the narrow gauge tracks near Taos, the spirit of the annual "railroad" express" was left intact as the nominating committee of John Pronos, Terry Shaw and Rich Hunt nominated Fields Cobb as Chairman and Walt Thies for Secretary-Treasurer for the 1985 Conference.

The meeting was adjourned with sincere thanks to the speakers, committees and especially to the local arrangements crew of Jerry Beatty and Ed Wood for hosting a great Work Conference.

## INTERIM PROGRAM CHAIRMAN'S REPORT

Paul F. Hessburg

The following topics were suggested for the 1985 WIFDWC meeting in Olympia, Washington.

### Program Suggestions:

1. Panel presentation or a series of special papers dealing with insect-disease interactions. (Fields W. Cobb)
2. Conduct a "hands on" session with the root disease model that was developed this past year. Model proposed and discussed by C.G. Shaw III at the 1984 meeting.
3. Panel presentation and discussion session dealing with genetic identification of Armillaria spp. in western forests.

Panel moderator: C.G. Shaw III  
Other suggested participants:  
D.J. Morrison  
N.E. Martin  
H. Burdsall

4. Laminated root rot program of papers and related field trip. Suggestions for content of special papers included the following subjects:
  - a. Basic biology and epidemiology (new work).
  - b. New root rot survey methods.
  - c. Application of computer simulation methods to forest growth and yield loss assessments.

- d. Control methods (new work, or progress on old work).
- 5. Panel presentation on the decision process for pest management (Ken Russell). Presentations should address all aspects of the process, including the biological, economic, political, and social concerns.
- 6. Panel discussion on hazard tree programs and pest management in recreation areas, to include discussion on the current status of such programs and worthwhile additions to them.
- 7. Discussion of training programs that are put on by forest pathologists for foresters and silviculturists. This could perhaps be accomplished through posters and/or displays.
- 8. Discussion panel on the status of research funding in the U.S. using data collected by the PAS Forest Pathology Committee.
- 9. Panel discussion on control of dwarf mistletoes using silvicultural methods within integrated resource prescriptions.

Discussion should include:

- a. Regional stand management concepts, silviculture, and harvesting methods (in summary form).
- b. Dwarf mistletoe detection: Special survey or incorporation into the

stand examination or other resource survey process?

- c. Stand treatment priority systems and disease control input into integrated resource prescriptions.
- d. Cutting methods
- e. Postsuppression activities.

Suggested participants:

J. Pronos, G. Filip or C. Schmitt or J. Hadfield, Beatty, Hessburg, Johnson, DeMitto, Hoffman.

Program Format and Procedural Suggestions:

- 1. Special papers should be one-half presentation and one-half discussion.
- 2. Streamline "new and old projects" reports by:
  - a. Not including States east of the Rocky Mountains.
  - b. Limit to one the number of speakers from each institution or group.
  - c. Limit the reporting time to 2 or 3 minutes for each speaker, only summarizing information on new people, new programs, new results or observations.
  - d. Do not list projects and evaluations in a lengthy, oral report; rather, enter listings for general perusal in the proceedings.

## STEM RUSTS COMMITTEE REPORT

3. Enforce "no smoking" in the meeting room, while providing an outdoor place for smokers to use as needed.
4. Extend the meeting by a day to allow more time for small group interaction.
5. Do not schedule program activities for the evenings.
6. Hold concurrent panels; this would allow us to cover a few more topics and would encourage more discussion and panel-audience interaction.
7. Keep the date of the field trip flexible to take advantage of the good weather.

Suggested Workshops: Root disease workshop - February 1986 in Portland, Oregon. (Greg Filip)

Brian Geils, Colorado State University, Ph. D. research on comandra blister rust was completed in August 1984. He studied three aspects of this disease in Colorado, Wyoming and Montana. The three research topics were an incidence survey of the Wind River District of the Shoshone National Forest, the development of cankers on lodgepole pine and the effects of the rust on the survival and growth of lodgepole pine. The disease incidence results will be reported in Plant Disease Vol. 68, No. 12. A brief explanation of the results of the other two research topics are found in a paper by B. Geils in these proceedings. Manuscripts have been submitted to Can. J. For. Res. and Forest Sci., respectively.

Ralph Zentz, Colorado State University, M.S. research on the epidemiology and risk rating of comandra blister rust is progressing well. The study deals primarily with the location of the alternate host and its relationship with the incidence of the disease on lodgepole pine. A brief report on our results to date are reported elsewhere in the proceedings.

Rich Hunt, Canadian Forestry Service, reported that a blister rust screening program for white pine was starting in British Columbia. A Ribes spp. garden was being developed in conjunction with Pacific Logging Ltd. and an inoculation facility at the Lake Cowichan research station of the B.C. Forest Service. The program will have input from the provincial silvicultural boards, Pathologist (Rich Hunt), breeder (Mike Meagher), biochemical genetist (Elanor White), 1.5 technicians and the B.C. Forest Service.

Addresses of the following attendees are in the directory and their prime rust interests are abbreviated beside their names:

Fred Baker CBR, WGR  
Jim Byler CBR, WGR, WPBR  
Hal Burdsall  
Fields Cobb WGR, WPBR  
Oscar Dooling CBR, WGR, WPBR  
Greg DeNitto WPBR  
Brian Geils and  
Bob Gilbertson CBR  
Frank Hawksworth P. bethellii  
Jim Hoffman WGR  
Rich Hunt WPBR, any  
Bill Jacobi CBR, any  
Dave Johnson CBR, broom rusts  
Bill Livingston  
Reed Miller  
Rober Webb C. quercuum in Cent.  
Am.  
Ralph Zentz CBR

The following persons interested in rusts are in the directory as WIFDWC members:

Eric Allen WGR  
Tom Beard SBR  
Yvonne Beaubien WGR  
Dave French WGR  
Bob Harvey WPBR  
Dick Heath WPBR  
Tom Hsiang WGR  
Neil Martin SBR  
Roger Peterson Gymnosporangium, any  
Bart van der Kamp WGR

Non-WIFDWC members interested in rusts include:

Bob Blanchette WGR, SBR  
Dept. Plant Pathology  
304 Stakman Hall  
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George Cummins any  
Dept. Plant Pathology  
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Yasu Hiratsuka Cronartia  
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Bob Stack Melampsora  
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Pete Theisen WPBR, WGR  
U.S. Forest Service  
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Portland OR 97208

Jim Walla WGR, Gymnosporangium  
Dept. of Plant Pathology  
North Dakota St. University  
Fargo ND 58105

ROOT DISEASE COMMITTEE  
HIGHLIGHTS OF THE 1984 MEETING  
GREG FILIP, CHAIRMAN

In February 1980, a root disease workshop was held in Corvallis, Oregon. A second workshop to be held in February 1986 at Portland was proposed. This would allow time for the development of the root disease submodel for the Stand Prognosis Model and subsequent reporting at the 1986 workshop. The following reports were submitted for inclusion in the proceedings:

ROOT DISEASE COMMITTEE REPORT  
JOHN PRONOS  
USFS, R-5, SAN FRANCISCO, CA

1. Somewhat unusual for California, A. mellea is killing ponderosa pine in 15- to 20-year-old plantations established on land that previously supported California black oak (Sequoia NF). The pines are being killed up to 65 feet away from very large oak stumps (30-60" diameter at the base).

2. Ponderosa and Jeffrey pine plantations (10-15 years old) in an old burn on the Sequoia NF are infested with both Fomes annosus and Armillaria mellea. It appears that F. annosus is the more aggressive pathogen, but it is moving from white fir stumps to pine saplings/poles, a situation not normally seen in natural mixed conifer stands in California.

3. A survey of 15- to 30-year-old Douglas-fir plantations on the Gasquet District, Six Rivers NF, is revealing low levels of mortality, but highly variable stocking. Black stain root disease has been identified in a number of these plantations. Attempts at determining differences in incidence of the disease between thinned and unthinned plantations are being complicated by the low levels of disease. Additional work on selected plantations to help clarify this situation is planned.

ROOT DISEASE COMMITTEE  
T. E. HINDS  
RM FOR. AND RANGE EXP. STA.  
FORT COLLINS, CO

A cooperative study between Forest Pest Management, Methods Application Group, Fort Collins, the Rocky Mountain Region, and the Rocky Mountain Station was conducted in 1983 to determine the degree of association between the mountain pine beetle and root disease (A. mellea) of ponderosa pine in the Black Hills NF, South Dakota. Twenty-nine stands in the southern, and 34 stands in the northern Black Hills were randomly selected for examination. The incidence of both A. mellea root disease and mountain pine beetle was high, being 89% and 78% respectively, of the sampled stands.

ROOT DISEASE COMMITTEE REPORT  
USFS, REGION 1  
MISSOULA, MT  
JIM BYLER AND SUE HAGLE

The Region continued work on root disease projects mentioned in last year's report, and initiated one new project.

A Case History of Root Disease Development in Unmanaged and Commercially Thinned Stands on the Fernan Ranger District.

The purpose of this new project is to measure mortality rates in affected stands, and to determine the effects of thinning on the rates. The project is to be continued for at least 5 years.

Regeneration - Permanent Plots

This is a continuing project, described in last year's proceedings. Plots were established in 13 more stands this year, to bring the total stands sampled to 20.

## Annosus Root Rot

Fomes annosus was found at a number of new locations this year. A description of several of the most notable findings is given below:

1. Jungle Point Seed Production Area, Lochsa Ranger District, Clearwater National Forest. A 35-year-old stand was thinned in the fall of 1983 to leave mainly Douglas-fir. Scattered Armillaria-associated tree mortality was recognized before thinning. During the winter of 1983-1984, about 20 trees were windthrown on the 20 acres. Most had extensive decay, and many had Armillaria fans at the root crown. Disks were cut from the stem and roots of a sample of the trees and incubated in plastic bags. Fomes annosus was identified on two of three windthrown Douglas-fir, one of one living Douglas-fir with root disease crown symptoms and Armillaria fans at the root collar, and one of one sampled grand fir stump.

2. Limber Luke Seed Production Area, Elk Ranger District, Nezperce National Forest. This 90-year-old stand was shelterwood cut 6 years ago, leaving about equal numbers of Douglas-fir and grand fir. Douglas-firs were dying, and Armillaria fans were common. Fomes annosus was cultured from the roots, from wood below Armillaria fans on three of four trees checked.

Grand fir appeared not to be killed, but decayed stumps contained annosus conks.

3. Schooner Creek Sale Area, Red River Ranger District, Nezperce National Forest. This area contained 70- to 150-year-old subalpine fir, Engelmann spruce, and some Douglas-fir. Some of the area had been commercially thinned in 1982. In the thinned stand, about 1/3 of the subalpine firs had windthrow with annosus root decay.

Standing mortality of subalpine fir was common in both cut and uncut stands. The spruce had root and butt rot, but no significant mortality. Most Douglas-firs had already died. Fomes annosus had been cultured from declining Douglas-firs in 1982, prior to any harvest activity in the stands. Armillaria was found in a 1982 examination of the stands, but not in 1984.

4. Ouzle Point Sale Area, Hungry Horse Ranger District, Flathead National Forest. This stand contained young pole-size subalpine fir, Douglas-fir, Engelmann spruce, lodgepole pine, and western larch which had been released by overstory removal in 1974. Subalpine fir and Douglas-fir were dying. Armillaria fans were present at the root collars of declining trees. Root samples were collected, and Fomes annosus was verified by culturing from both species.

5. Mountain Meadows Root Rot Salvage Sale Area, Red River Ranger District, Nezperce National Forest. Root disease centers were evident on aerial photographs in these 80-year-old stands. This area has not had any cutting. Subalpine fir and lodgepole were dying. Abundant and vigorous Armillaria fans were present on dead and declining trees of both species. Fomes annosus was cultured from subalpine fir and spruce, but not yet from lodgepole pine.

## Discussion

Fomes annosus has been recognized as a root pathogen in Region 1 since the late 1930's at least. However, most of our recent annosus findings have been in either low-elevation ponderosa pine stands or high-elevation subalpine fir stands. This year's findings appear significant for several reasons:

1. Douglas-fir was a major species affected and was on productive mid-elevation sites.

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## DISEASE CONTROL COMMITTEE

### 1984 INVESTIGATIONS

Kenelm Russell, Chairman

New to the committee this year is the addition of dwarf mistletoe control results. Traditionally, they have been reported in the dwarf mistletoe committee. They will now appear here and under some circumstances in the DM committee report.

Since this is your disease prevention/control catalogue, we thought it a good idea to have "applied" results in one place. Flexibility allows you to decide where you want your information to appear.

We've come full circle. This committee was born when we met in Santa Fe in 1967 and has undergone few changes since. I'm looking for ways to bring more information to you and to provide some sort of a continuum for disease management. One way, is to make space available for you in our proceedings report to sound off on any disease management topic. I'll kick it off. . .

My reason for writing on this subject is to find out what the rest of you think about this problem. The following discussion relates a proven and simple prevention plan developed over twenty years or so. What can you add to improve it? The idea is to leave a clear track about a particular disease and its prevention and management. Our annual reports can become a forum that help pull widespread research projects together into actual disease management concepts. It is a group effort-Let's hear it!

#### SOUNDING OFF - TOP BLIGHT IN NURSERIES

Perhaps one of the most commonly reported nursery disease problems over the years is the so called Top Blight of first or sometimes second year seedlings. Usually Fusarium is involved (at least in several of our Pacific Northwest nurseries). Other fungi are certainly capable of causing Top Blight as well.

Many years ago, I caught the fungus (*Fusarium* spp), literally with its pants down, and identified it on the spot. (Its conidia were showing on the stems near the root crown on one year Douglas-fir seedlings.) I've since named it the "Fourth of July Disease" because that is when we often begin first seeing it west of the Cascade Mountains.

The reason the disease hits around mid-summer in the Northwest is twofold (or maybe more). Since hot summer days can kill tender seedlings, it is sometimes necessary to water for cooling. Unless this is very skillfully done, seedlings become set-ups for disease invasion. Cooling irrigation is often done daily during the hottest days. This

frequent and light watering pattern creates a warm, moist microclimate near the soil surface well suited for *Fusarium* to infect mildly stressed trees.

The seedlings may become stressed during this time because their deep roots are not getting enough water. The minimal cooling water stays near the surface and the roots are two to five inches straight down in considerably drier soil. (Try digging in a nursery bed on a hot summer day and you may see this condition.)

The rest of this story is that seedlings may not have adequate preventive fungicides on them at this critical time. A regular application schedule will help reduce or prevent infection, provided it is not washed off by the frequent watering. Fungicide schedules must be coordinated with rain and watering so that the treatment is not washed off the target before it is absorbed or otherwise activated. I have seen many cases where fungicides are properly applied, then promptly washed off.

Top Blight can be minimized or halted before it shows by watering less frequently and for longer periods. This pattern of watering must be done in consort with a carefully orchestrated fungicide application plan. The plan should include alternate fungicides so that no one fungus gets the upper hand.

The infrequent, deep watering approach is not really quite this simple because the grower wants to slowly harden the seedlings off for the approaching fall. This is usually done by withholding water and nutrients. Growers walk a tight wire between disease development and hardening off at this point in the season. Personally, I would rather water deep in hot July and harden off a little later after the temperatures drop slightly.

This is where the green thumb comes in. In many nurseries the watering schedule has become too mechanical. The person responsible simply turns valves on and off for a specified number of minutes without ever looking at the trees. THESE PERSONS SHOULD BE HIRED FOR THEIR GREEN THUMBS. They will know when the water is just right and quite effectively minimize disease.

In addition to deep watering and fungicides, Top Blight potential may also be reduced by skillful use of nutrients. There is evidence that nitrogen, in particular, enhances development of *Fusarium*. Minimize mid-summer applications of nitrogen fertilizers.

All growers and their helpers should be carefully trained: first, to prevent Top Blight, second, to recognize build-up conditions and remedy them, and third, to recognize symptoms and treat the actual disease. I've seen some excellent results when growers follow these principles of Integrated Pest Management.

## SEEDLING DISEASES

### 1. Charcoal Root Rot

Host: Sugar Pine, Douglas-fir, White Fir, Ponderosa Pine, White Pine  
Causal Organism: Macrophomina phaseolina  
Control: Biological  
Development Stage: Field Trial In Vitro

Inoculum density trials, may show tolerance in nursery to low levels in the soil. Tests to be completed Fall 1984 (McCain, Bega).

### 2. Damping-Off

Host: Lodgepole Pine  
Causal Organisms: Fusarium spp., Pythium spp.  
Control: Solar Heating  
Development Stage: Field Trial

In 1983, soil solar heating field trials were begun at the Bessey Nursery, Nebraska. Three check plots were left fallow and 3 treatment plots were irrigated and covered with clear polyethylene tarp for 7 1/2 weeks beginning in later June. Tarps were removed in late August. Populations of Pythium spp., Fusarium spp., weeds, and nematodes were monitored before and after solar heating. Sorghum sudan was planted as cover crop after tarps were removed. In Spring, 1984, lodgepole pine was planted. Three additional plots were established in fumigated beds for the same seed lot planted at the same time. Pest populations were sampled twice, and seedling survival was counted several times in Summer, 1984.

Populations of Pythium spp., Fusarium spp., weeds, and plant-parasitic nematode genera (Trichodonus, Tylenchorynchus, Tylenchus, Helicotylenchus, Xiphinera, Pratylenchus) were significantly reduced by solar heating. Although the Bessey Nursery has had a history of problems with the root lesion nematode (Pratylenchus penetrans) (Cobb, Sher and Allen), very few of these nemas were found in any of the sample plots at any time. All parasitic nematodes population levels were low in all plots, possibly due to soil disturbance from installation of a new irrigation system in June, 1983.

Counts made of surviving lodgepole pine seedlings, indicated that seedlings survived much better in fumigated soil, while solar heated and check plots supported similar lower survival rates. Technical report available winter 1985 (D. Hildebrand).

### 3. Phoma Blight

Host: True Fir  
Causal Organism: Phoma eupyrena  
Control: Chemical  
Development Stage: Field Trial

Two treatments, a redwood mulch and a lath shade cover, reduced soil cone formation and incidence of Phoma blight (Kliejunas, McCain, Allison).

### 4. Sirococcus Tip Blight

Host: Jeffrey Pine  
Causal Organism: Sirococcus strobilinus  
Control: Chemical  
Development Stage: Field Trial

Tilt 3.6 EC applied at 4 week (2% infection) and 8 week (4% infection) intervals was more efficacious than the currently recommended 4 week (8%) application of Bravo W-75 (Kliejunas, McCain, Allison).

### 5. Top Blight

Host: Douglas-fir (1-0)  
Causal Organism: Phoma/Fusarium  
Control: Chemical  
Development Stage: Field Trial

Timing of fungicide treatments is being evaluated at Aurora, Oregon nursery. Using Benlate/Daconil and Benlate/Difolatan tank mixes. Results due March 1985 (A. Kanaskie).

### 6. Top Blight

Host: Douglas-fir  
Causal Organism: Phoma/Fusarium  
Control: Chemical  
Development Stage: Field Trial

Biweekly applications of Benlate, Difolatan, Mertect 340 Daconil 2787, Chipco 26019, and Zyban at two nurseries using operational spray equipment. Cooperative project with USFS, Portland. Evaluations in Fall 1984, Spring, 1985, Fall 1985 (A. Kanaskie, S. Cooley).

### 7. Douglas-fir Top Blight

Host: Douglas-fir  
Causal Organism: Phoma spp./Fusarium spp.  
Control: Chemical  
Development Stage: Field Trial

Benlate, Difolatan, Daconil 2787, Chipco 26019, Captan, Mertect, and Zyban being applied to 1984-sown Douglas-fir at 5 nurseries in Oregon and Washington. Applications made at 2 week intervals, July-September. Two nurseries extending applications through spring 1985. First evaluation of fungicide effectiveness will be made October 1984 (S. Cooley, Phil Hamm, Alan Kanaskie).

### 8. Phytophthora Root Rot

Host: Douglas-fir  
Causal Organism: Phytophthora spp.  
Control: Chemical  
Development Stage: Field Trial

Metslaxyl (Subdue ZE) and phosethyl-A1 (Alette) applied to symptomatic 2-0 and asymptomatic 2-1 (spring transplanted) Douglas-fir seedlings. Two applications of metalaxyl (June and November, 1984 and 5 applications of phosethyl-A1 (June, July, October, November, and December, 1984) will be made. Treated and control seedlings will

6. Phellinus Root Disease

Host: Douglas-fir  
Causal Organism: Phellinus weirii  
Control: Silvicultural - Mechanical  
Development Stage: Pilot Operational

Stump removal and root raking trial established on 24 ha near Naswhito Creek, Vernon (E. Haupt, R. Smith).

7. Blackstain Root Disease

Host: Pinyon Pine  
Causal Organism: Ceratocystis (Verticicladiel wageneri)

Control: Chemical  
Development Stage: Field Trial

Several treatment plots established in 1982. Three plots at Mesa Verde had a trench dug to sever roots on far side of next healthy tree away from black stain root disease center. Three plots at Mesa Verde had the fumigant VAPAM injected to kill roots on far side of next healthy tree away from disease center. In all 6 plots, the 1984 checkup revealed the fungus had already breached the control barrier probably before the control treatments.

Also in 1982, 5 silvicultural treatment plots San Juan National Forest (Colorado). The next two healthy trees were removed (cut) from the perimeter of the blackstain root disease center. The 1984 checkup revealed that the fungus had breached the silvicultural barrier much less frequently than in the other control plots (Dave Johnson).

RUSTS

1. White Pine Blister Rust

Host: Western White Pine  
Causal Organism: Cronartium ribicola  
Control: Silvicultural  
Development Stage: Operational

Pruned a small stand of white pine in Columbia River Gorge near Stephenson, WA. Trees average 31 feet tall and 6.9" d.b.h. in 14 years. Twenty-seven percent of dominants had cankers but not the killing kind.

In a separate tally of all trees, 54% of trees were still free of rust. Average canker height was 3.4 feet + 2.8 feet. We feel that pruning will bring most of the dominant trees to rotation (Russell).

2. White Pine Blister Rust

Host: Western White Pine  
Causal Organism: Cronartium ribicola  
Control: Silvicultural  
Development Stage: Pilot

Two separate outplantings of white pine were compared. One used pullups and a second used seed from rust resistant trees (untested). After 3 years, rust on pullups was about one third of total. Rust on seed from open

pollenated resistant parents is still zero. Location of the plantations may be a factor, but we are encouraged by the dramatic difference. We are also pruning as the trees grow, leaving only 2 whorls (Russell).

3. Stem Rusts and Cankers

Host: Lodgepole Pine  
Causal Organism: Endocronartium harknessii, Atropellis, etc.  
Control: Silvicultural  
Development Stage: Field Trial

Monitoring stem disease incidence and build-up in young pine stands "spaced" and control (no spacing) in conjunction with study initiated by B. VanderKamp, University of British Columbia (E. Wilford, A. Vyse).

4. White Pine Blister Rust

Host: Pinus monticola  
Causal Organism: Cronartium ribicola  
Control: Silvicultural  
Development Stage: Full Operational

Branch pruning young white pine on 44ha, Beavertail Lake area. Further 100ha planned (D. Harris).

DWARF MISTLETOE

1. Dwarf Mistletoe

Host: Lodgepole Pine  
Causal Organism: Arceuthobium americanum  
Control: Silvicultural  
Development Stage: Pilot Operational

Sanitation of "young" or small residual trees following harvesting conducted on 100-200 ha in Cariboo region (Palmer Lake Road area) using fire suppression crews.

Unacceptable looking trees - those with scars, gall rust, logging damage, visible (severe) mistletoe were cut using hand double action shears and remaining trees were spaced to approximately 2000 trees per hectare (2m spacing interval).

This type of treatment seems more desirable on drier pine sites where regeneration following complete eradication of all residuals e.g., by drum chopper is expensive, difficult or too successful (overstocking). Thresholds of mistletoe incidence in residuals need to be determined (E. Wilford).

2. Dwarf Mistletoe

Host: Lodgepole Pine  
Causal Organism: Arceuthobium americanum  
Control: Silvicultural  
Development Stage: Pilot Operational

Thinning of 40-year old pine stand to show (demonstrate) returns from thinning and mistletoe sanitation of older immature stands.

Results should be compared with yields predicted by "LPMIST" (RMYIELD) stand projection model (J. Muir, E. Begin).

## ROOT DISEASE (CON'T)

3. Dwarf Mistletoe  
Host: Lodgepole Pine  
Causal Organism: Arceuthobium americanum  
Control:  
Development Stage: Full Operational

Establishment of a demonstration area (200-300+ha) showing harvest block layout, fringe felling and fringe planting to deal with mistletoe. These were industrial operational treatments.

Fringe-planted Douglas-fir is being outgrown by naturally regenerated pine (J. Muir, E. Begin).

4. Dwarf Mistletoe  
Host: Western Larch  
Causal Organism: Arceuthobium laricia  
Control: Silvicultural  
Development Stage: Pilot Operational

Thinning/sanitation project of 15-18 year-old larch-lodgepole pine stands. Seven one-hectare blocks showing various treatments: no thinning, removal of overstory (residual) trees, spacing with or without sanitation for mistletoe.

Initial treatment costs were high and results not too satisfactory in spots because of timing of treatment (December) and urgency to establish the demo (J. Muir, S. Byford).

2. Armillaria fans were abundant at the root crowns of dead and declining trees from which Fomes annosus was recovered.

3. Fomes annosus would not have been recognized as a pathogen in these areas if samples had not been collected for incubating or culturing.

Based on these findings, we suspect that annosus root disease may be present in other stands where only Armillaria has been found, and the Fomes annosus-caused root decay may be predisposing trees to Armillaria attack. More work is needed to test these hypotheses.



Western International Forest  
Disease Work Conference  
Mistletoe Committee Report  
1984 Highlights

John G. Laut, Chairman

I. Taxonomy, Hosts and  
Distribution

- A. Rocky Mtn. bristlecone pine (Pinus aristata) is a rare host for Arceuthobium vaquinatum ssp. cryptopodum but this host/parasite combination has been found in two new areas in 1984: central Colorado (South Park, by Co. St. Forest Service), and northern New Mexico (Valle Vidal Tract, by R.L. Mathiasen). (F.G. Hawksworth, RMFRES, Ft. Collins CO)
- B. A new dwarf mistletoe, A. pini var. sichuanense, a parasite of Picea, was described by Kiu in southwestern China. (see item xii-D below)
- C. Arceuthobium occidentale was found infecting Aleppo pine (P. halepensis), near Kernville, California in Sept. 1984. Three Aleppo pines planted within 100 ft. of a native Digger pine (P. sabiniana) bearing numerous dwarf mistletoe plants, were all infected by the parasite. One pine nearest the source of dwarf mistletoe was very heavily infected. Observations indicate that P. halepensis is highly susceptible to this species of dwarf mistletoe, and that the parasite is able to grow and reproduce well on this pine. (R.F. Scharpf, PSW, Berkely CA)

II. Physiology and Anatomy

- A. Concentrations of plant growth substances were measured in black spruce (Picea mariana) tissue infected with eastern dwarf

mistletoe (A. pusillum). Concentrations of zeatin riboside ( up to 65 ng/gfw) and indole-3-acetic acid ( 479 ng/gfw) were higher in infected tissue, but these differences were detectable only in the spring. Concentrations of abscisic acid (ABA) (37-1546 ng/gfw) were significantly lower in infected tissue vs. noninfected tissue during April-October. Experiments to ascertain if exogenous applications of ABA could disrupt the assimilate transport from noninfected tissue to infected tissue will first be made with dodder (Cuscuta) in the laboratory, and then with dwarf mistletoe in the field (W.L. Livingston, M.L. Brenner and R.A. Blanchette U. of Minn. St. Paul MN)

III. Life Cycle Studies

- A. A total of 1450 plots (established at 10-m grids) was evaluated in a 60-ha, 7 yr.-old lodgepole pine stand on the Fraser Experimental Forest, Colorado, to determine presence or absence of dwarf mistletoe and to identify satellite infection centers that may have originated from vector-carried seed. Of the 1450 total, 218 plots were located in a non-lodgepole pine type. Of the remaining 1232 plots 871 were infested with dwarf mistletoe. Twenty-five satellite infection centers were found within the lodgepole type that otherwise had no mistletoe, or about 1.7 centers/ha. The number of infected trees in these satellite centers ranged from one to 10 trees (mean 3.5). Most of these areas were along the edges of old logging roads or other forest openings favored by birds. All 25 satellite infection centers were too far removed

from main infection centers, or too protected by healthy trees to have originated from seeds expelled from mistletoe fruits alone. Distances from main infection centers ranged from 12 to 65 (avg. 27) m. Ages of each center are being determined. (F.G.Hawksworth RMFRES, & T.H.Nicholls and L.M.Merrill NCFES)

B. Ten bird and four mammal species were identified as potential vectors of lodgepole pine dwarf mistletoe at the Fraser Experimental Forest, CO during 1982 and 1983. A total of 626 birds, of 30 species, and 300 mammals, of four species, were trapped and examined for seed. Seven percent of the birds and 9 % of the mammals trapped carried seed on their bodies. Both resident and migratory birds were captured with seeds on their feathers. The most important vectors were the gray jay, Stellar's jay, mountain chickadee, and least chipmunk. Telemetry studies of gray jays in 1983 verified that birds frequently move back and forth between infected and healthy stands, and that their home range varied from 52-126 acres. Several gray jays trapped and banded in 1982-83 were retrapped in 1984, in the same location they were previously trapped. This suggests that these birds, over time, can accelerate the intensification of local dwarf mistletoe infestations. (T.H.Nicholls, F.G.Hawksworth, L.M.Merrill, L.M.Egeland, NCFES & RMFRES)

IV. Host Parasite Relations - no reports

#### V. Effects on Host

- A. Sixteen permanent, 100-tree plots were established in lodgepole pine stands on the Targhee National Forest, Idaho. The objectives are to determine the following:
1. The effects of precommercial thinning on growth of lodgepole pine stands to various intensity levels of dwarf mistletoe parasitism;
  2. The effects of dwarf mistletoe parasitism on lodgepole pine volume yields; and
  3. The changes in dwarf mistletoe incidence and intensity over time as a result of thinning.

The next recording of plot data is scheduled for 1988. (Hoffman, R-4).

B. Analysis continues on 1983 data collected from 806 dwarf mistletoe-infected Douglas-fir trees in southwestern Idaho. The purpose of this evaluation is to determine the effects of various levels of dwarf mistletoe infection on Douglas-fir growth and volume yields. The information will be used to develop Regional cutting guidelines to optimize harvesting of infested stands. Growth modifying information will also be used to compliment research efforts in development of a southern Idaho Stand Prognosis Model. (Hoffman, R-4, Ogden UT)

C. A project funded by the Employment Bridging Assistance Program, administered by Canadian Forest Products Ltd., and with technical direction of PFRC researchers, provided substantial information on the impact of dwarf mistletoe (A. tsugense) on western hemlock. Some 210 trees, varying in infection level

from healthy to severe, from 5 locations on northern Vancouver Island were felled, disks removed and growth patterns analysed. The field portion of the study was conducted in the winter of 1983-84. Analyses follows procedures established by Thompson et al (see list of publications in this Proceedings). Total volumes for periods since release of 45-80 years depending on the stand, were 24-52 percent less for severely infected vs. healthy trees. (Al Thompson, Rene Alfaro, Bill Bloomberg, Dick Smith, PFRC, Victoria BC)

- D. Helen Maffei's Ph.D. research on the effects of dwarf mistletoe on uneven-aged ponderosa pine in Colorado is progressing. Eighteen paired temporary plots were established along the "Front Range" to assess the effects of dwarf mistletoe on growth and mortality of ponderosa pine. The data will be analyzed and results available by fall 1985. This information will be used in the growth and yield model being developed by E.B. Edminster of the RM Station. (H. Maffei, B. Jacobi, CSU and F.G.Hawksworth, RMFRES, Ft. Collins CO)

#### VI. Ecology - no reports

#### VII. Control - Chemical

- A. Ethephon, an ethylene releasing agent, is most effective in stimulating abscission of eastern dwarf mistletoe (A. pusillum) shoots when it is applied in late summer, at 2500 ppm, and with a surfactant. Additional tests with other ethylene releasing agents and different surfactants are in progress in northern Minnesota. The treatment can cause death of infected

brooms, but no other adverse effect on the host tree has been observed. Regrowth of aerial shoots remain unaffected after treatment. Comparing results of studies completed in Minnesota with those of T. Nicholls (N.C. Station) on A. americanum in Colorado indicate ethylene releasing agents are best suited for controlling spread of dwarf mistletoe arising from localized infections. Complete abscission of aerial shoots on localized infections can apparently prevent seed dispersal for long as 5 years. Ethylene releasing agents would be suitable for aiding trees to outgrow dwarf mistletoe infections in recreational areas. (W.H.Livingston, R.A Blanchette and M.L. Brenner U. of Minnesota, and T.H.Nicholls, N.C. Station St. Paul MN)

- B. Chemical tests on A. vaginatum on ponderosa pine near Estes Park, CO were continued in 1983. About 2 chemicals on over 400 trees were tested. Most chemical were applied as sprays but trunk injections through ba slits, and Mauget injectors were also tried. None of the chemicals tested killed the endophytic system although several were very effective in killing aerial shoots. The sprays that were most effective in killing shoots that is, more than 90% of a shoots killed in all tests) were butyrate ester of 2,4-Roundup (glyphosphate); D-4 (ethanol isopropanol salt of 2,4-D); Rhone Poulenc 2,4-D and emulsamine (dodecyl and tetracyclamine salts of 2,4 D). Slit injections were less effective, and the highest shoot kill was 85% (for simazine). Mauget injections of Ethrel, Atrinal, Regulator, and Embark all caused sufficien

shoot loss so that no fruits matured in any tests, but overall shoot mortality was not as high as for spray trials. Tests are continuing. (A. Moinat, Estes Park CO)

- C. Growth regulators are being tested as a potential control for A. americanum on lodgepole pine on the Fraser Experimental Forest, CO. Forel applied in 1983 caused shoots to drop before the berries ripened, but did not kill mistletoe tissue under the bark. By 1984, new shoots developed at the margins of infected tissue. It will take 3-4 years before these new shoots mature. Additional plots were established in August 1984 to test Ethrel and CGA 13586 with two spreader-stickers. Growth regulators were applied with hand sprayers and backpack mistblowers. (T. H. Nicholls, F. G. Hawksworth and L. M. Egeland; NC and RM Sta.)

#### VIII. Control - Biological

- A. In 1970 we summarized the literature on insect and mites associated with dwarf mistletoes. We are now reviewing what has since happened in the field, and the paper will be published in the proceedings for the symposium on Biology of Dwarf Mistletoes. There are 3 main relationships between arthropods and dwarf mistletoes: (1) insects that feed on mistletoe shoots, fruits, flowers, and seeds, (2) insects that pollinate dwarf mistletoes, and (3) insects that attack trees weakened by dwarf mistletoe. (R. E. Stevens, CSU and F. G. Hawksworth, RMFRES Ft. Collins CO)

- B. Dwarf mistletoe plants (A. abietinum f.sp. magnificae) on high elevation red fir (Abies magnifica) in California were found to be severely parasitized by brown felt blight (Neopeckia-Herpotrichia complex). Most infections on smaller trees or in the lower crowns of trees that were under snow (12-15 feet above the ground line in many areas) bore severely parasitized shoots or were devoid of shoots in 1983, 1984. Infections above snow line showed little parasitism and a higher proportion bore healthy shoots. (R.F.Scharpf, PSW, Berkeley CA)

- C. In summer, 1984, grasshoppers (Melanopus destructor) effectively removed most aerial shoot growth of A. campylopodum growing on jeffrey pines in an experimental plantation at the Institute of Forest Genetics, California. Unfortunately dwarf mistletoe shoot development and fruit production were part of the study. 1984 was apparently a banner year for grasshoppers in many parts of the west, and parts of California were no exception. At IFG, the insects apparently built up and fed on grasses and other preferred food plants, and then migrated to the pines and dwarf mistletoes when these primary food sources became scarce. Thus, in spring we observed no damage to the dwarf mistletoe, but by September nearly all shoots on 185 dwarf mistletoe plants within 6 ft. of the ground were gone. Grasshoppers were observed feeding on shoots at various times during this interval. Grasshoppers caged with pine branches bearing dwarf mistletoe plants confirmed their preference for dwarf mistletoe over pine. No

damage was observed to pine foliage in the plantation. (R.F.Scharpf, PSW, Berkeley CA)

## IX. Control - Silvicultural

- A. Activities to suppress dwarf mistletoe during 1984 in California recreation areas included branch pruning, broom pruning and tree removal. In all cases the primary target was A. campylopodum on ponderosa and Jeffrey pines. The control projects were done in six campgrounds and included both National Forest (Angeles, San Bernardino, Lake Tahoe Basin) and National Parks (Sequoia and Kings Canyon) lands. (Vogler, R-5, San Francisco CA)
- B. Dwarf mistletoe suppression projects were conducted over 3,013 acres on six National Forests in southern Idaho during 1984. (Hoffman, R-4, Ogden UT)
- C. Plans are to treat 5,220 acres of A. americanum infested lodgepole pine stands on the Arapaho and Roosevelt; Grand Mesa, Uncompahgre, and Gunnison; Medicine Bow; Pike and San Isabel; Routt; Shoshone; and White River National forests. (D.Johnson, R-2 Denver CO)
- D. Sanitation of young or small residual lodgepole pines following harvesting was conducted on 100-200 ha in the Cariboo Forest Region (Palmer Lake Rd. area) using fire suppression crews during periods of low fire hazard. Unacceptable looking trees, e.g. severely suppressed, scarred, rust-galled, logging damage and visible dwarf mistletoe, were cut using double-action hand shears. Remaining trees were spaced to approximately 2000 stems/ha (2m spacing). This

type of treatment seems desirable on dry sites where regeneration following eradication of all residuals e.g. by drum chopper, is expensive, difficult, or results in overstocking. Mistletoe incidence in cut-over areas which received treatment needs to be determined. (E. Wilford & J.Muir, BC M.of F. Victoria BC)

- E. Demonstration areas for dwarf mistletoe control were set up in three areas of SE British Columbia: A. A sanitation thinning was established in 15 - 18 yr. old western larch and lodgepole pine mixed stand, with both A. laricis and A. americanum, near Kimberley. Seven 1-ha blocks included; no thinning, overstory removal and thinning with and without regard for mistletoe in the trees. B. An overstocked, 40-yr. old stand of lodgepole pine near Invermere, infected with mistletoe (DMR 3-4), was thinned to show possible benefits in terms of future yield. C. An area of mature lodgepole pine, 200-300 ha, near Radium, was logged and treated in several ways by a forest industry company. This area was designated as an operational demonstration (J. Muir & Nelson Forest Region staff, BC M.of F. Victoria BC)

## X. Surveys

- A. Presuppression surveys for A. americanum are planned for 11,550 acres on the Medicine Bow; Routt; Shoshone; and White River National forests (Johnson, R-2 Denver CO)

## XI. Miscellaneous

A. R.C. Thobium was the recipient of a signal honor recently!! R.C. (better known to non-mistletoers as Frank Hawksworth) was awarded the Barrington Moore Memorial Award for 1984 by the Society of American Foresters at their annual meeting at Quebec City. This award is one of the Society's most prized awards for scientific achievement. It is awarded for "distinguished, individual research in any branch of the biological sciences that has resulted in substantial advances in forestry,...."  
Congratulations Frank, from all of WIFDWC.

B. The following letter was sent to State of Oregon Dep't. of Forestry and is included here to give us all some food for thought (NO KIDDING - this is for real):

Dear Sirs:

We recently made a motor trip from Bandon to Klamath Falls, OR. This route took us through much of the lumber country and the pine forests there.

We noticed a number of trees dying from a yellow mistletoe type of parasite. We photographed some of these and upon our return had this analyzed atomically.

The atom responsible is Uranium having 92 electron atoms and in such growths in tree or man forms a fungi that is deadly, especially when it gets in the bloodstreams of man or the sap stream of a tree.

How does the uranium get there? It has only two ways, 1) from fallout, and 2) by induction from uranium in the soil. In man it acts like leukemia, but it isn't.

We thought you undoubtedly are concerned about this and if you haven't pinned down a cause, you might like the atomic answer.

Sincerely yours,

for obvious reasons (libel?), I have not identified the author of this letter (JGL)

C. D.W.Johnson and F.G.Hawksworth have completed a manuscript entitled "Dwarf Mistletoes: The Ideal Candidates for Control Through Cultural Management". This report, which will be issued by the Forest Pest Management unit, USFS, Washington office, summarizes the biology of these parasites, host growth loss and annual mortality in the U.S. and cultural control techniques. The intended audience is the lay person, not practitioners.  
(D.Johnson, R-2, Denver CO)

XII. Special Section---The following abstracts of papers presented at the AIBS Annual Meeting, Ft. Collins Co., Aug. 6-10 1984 are published in American Journal of Botany, 71(5), Part 2, 1984 (abstract nos. 157-170). They are included here for the convenience of WIFDWC members. The full papers are to be published as a Station Paper from RMFRES (USFS).

A. Alosi, M. Carol & Clyde L. Calvin. Dep't. of Biology, Portland State University. - The morphology of the endophytic system of Arceuthobium spp. The part of the dwarf mistletoe plant that develops within the host plant is termed the endophytic system. During establishment of the parasite in new areas of host stem, endophytic cells grow

intrusively. After this initial invasion, the development of the endophytic system becomes attuned to the growth form of surrounding host tissues: In host secondary tissues, endophytic cells, after intrusive growth to the host cambium, develop a meristem in line with the host cambium. Derivatives are produced by (mainly) periclinal divisions in coordination with the host xylem and phloem production. The newly-formed endophytic cells become integrated with juxtaposed host ray cells to produce a chimera-like unit called an infected ray or sinker. In this regard sinkers of Arceuthobium differ from those of Phoradendron since the latter have sinkers composed exclusively of parasite cells. A few species of Arceuthobium invade host primary vasculature. Subsequent growth of endophytic tissue follows the form of surrounding host cells--i.e., growth by cell elongation with predominantly transverse division planes. In a given region of host shoot, sinkers are not produced until the host stem converts from primary to secondary growth. The relationship of Arceuthobium endophytic cells with host tissue reflects great tissue compatibility and careful evaluation of cytological features may be required to distinguish host from parasite cells. The organisms share a common apoplast, though symplastic continuities are doubtful. Certain subcellular features of endophytic cells may facilitate nutrient uptake and transport.

B. Gilbert, Jeannie & David Punter. Dep't. of Botany, Univ. of Manitoba. The pollination biology of Arceuthobium americanum in Manitoba. There is evidence that both entomophily and anemophily play a significant role in the pollination of A. americanum. The most commonly trapped insects, a Bradysia sp. (Diptera) and Formica spp. (Hymenoptera) are thought to be involved in chance pollination of the mistletoe. Among the Coleoptera, Hyperaspis binot Say (Coccinellidae) and Cyphon sp. (Helodidae) were frequently found bearing mistletoe grains on both male and female brooms. Where female brooms were isolated from male brooms only 8.75% of the insects trapped bore pollen, while 79% of the flowers were pollinated. These data, together with the recovery of airborne pollen at least 400 m from a source indicate that anemophily is also a significant pollinating mechanism.

C. Hawksworth, Frank G. & Delbert Wiens. USDA Forest Service, RMFRES, and Dep't. of biology, Univ. of Utah. Biology and classification of Arceuthobium: an update. Arceuthobium is unique in that it is the only mistletoe genus that occurs in both the New and Old Worlds. In our 1972 monograph, we recognize 32 taxa, 28 in the New World and 4 in the Old. Since then, 9 new taxa have been described or recognized: 5 in the New World and 4 in the Old. Most of the new taxa in the New World are on Pinus: A. aureum ssp. aureum in Guatemala and Belize, A. aureum ssp. petersonii in southern Mexico, A. globosum ssp. grandicaule in Mexico and Guatemala, and A. pender in central Mexico. The most surprising is the recent

discovery of a new species (A. cubense) on Podocarpus in eastern Cuba. This is the first reported host of Arceuthobium in the Podocarpaceae. In the Old World, the recently described or recognized taxa are: A. azoricum on Juniperus in the Azores, A. juniperi-procerae on Juniperus in Ethiopia and Kenya, A. tibetense on Abies in southwestern China, and A. pini var. sichuanense on Picea in southwestern China. The greatest increases in the number of known taxa since 1972 has been in China (2 to 6), Guatemala (2 to 5), and Mexico (16 to 19). Arceuthobium is reported for the first time in El Salvador and Cuba. Pinus is the primary host of the genus (25 of 41 taxa), but of only 2 of the 8 Old World taxa. New host and distribution records for Arceuthobium will be summarized.

- D. Kiu, Hua-Sing, South China Institute of Botany, Kwangchow, China. Arceuthobium and its hosts in Southwestern China. Until recently only two species of Arceuthobium were known from China: A. chinense on Abies and Keteleeria in Yunnan and Szechwan and A. pini on Pinus in Yunnan and Szechwan. Recent research has shown that 3 more taxa are members of the Chinese flora: A. oxycedri, a widespread parasite of Juniperus in Asia and the Mediterranean, was found in several localities in Xizang (Tibet). Two new taxa are described: A. tibetense, a local species on Abies in Xizang and A. pini var. sichuanense, a common parasite on Picea in Xizang and Szechwan.

- E. Knutson, Don M. Department of Botany and Plant Pathology, Oregon State University, Corvallis, OR 97331. - Seed development, germination behavior and infection characteristics of several species of Arceuthobium. Fruit and seed development were monitored throughout the growing season for 5 species of Arceuthobium. Final seed weights compromise 15 percent of total fruit weights, with viscin accounting for 30 percent of seed weights. Germination, radical growth and rate of infection were highest in an environment of high light, high relative humidity and low temperature. Number of aerial shoots produced was greatest at higher temperature and low light. Germination readiness and tropistic responses also characterize seeds of Arceuthobium species.

- F. Linhart, Yan B. Biology, University of Colorado, Boulder, CO 80309 - Relationship between genetic constitution and host preference in the dwarf-mistletoe Arceuthobium vaginatum. A. vaginatum subsp. cryptopodum is parasitic on several pines in Colorado. Its usual host is Pinus ponderosa, but it also grows on P. flexilis and P. contorta. The genetic constitutions of Arceuthobium populations growing on these three hosts are analyzed electrophoretically; all are highly variable. Evidence about the formation of host races is presented.

- G. Livingston, William H., Department of Plant Pathology, Mark L. Brenner, Department of Horticulture and Landscape Architecture, and Robert A. Blanchette, Department of Plant Pathology, University of

Minnesota, St. Paul, MN 55108. - Lower levels of abscisic acid associated with eastern dwarf mistletoe infection in black spruce. Black spruce (*Picea mariana*) tissue, infected and noninfected with eastern dwarf mistletoe (*Arceuthobium pulillum*), was analyzed monthly from April to October, 1982, for abscisic acid (ABA), indole-3-acetic acid (IAA), zeatin, and zeatin riboside. High performance liquid chromatography was used to purify all plant extracts and to analyze levels of IAA, zeatin, and zeatin riboside. ABA levels were analyzed using gas chromatography. Of all the plant growth regulators ascertained, the only significant difference which could be detected was in ABA concentrations. For each sample period, ABA levels were always higher (1.43 to 5.16 times) in noninfected tissue compared to black spruce tissue infected with dwarf mistletoe.

H. Mathiasen, Robert L. and Elizabeth Blake. School of Forestry, Northern Arizona University, Flagstaff, AZ 86011. - Relationships between dwarf mistletoes and habitat types in western coniferous forests. Few quantitative data are available on the relative frequency or severity of dwarf mistletoes in different habitat types. Infection of ponderosa pine has been shown to be more prevalent and severe in habitat types representing low productivity potential or more xeric sites. Habitat type classifications have primarily designated the prevalence of dwarf mistletoes in different habitat types using qualitative rating systems

such as high, moderate, and low. Our analyses of height-age relationships for Douglas-fir indicated there are significant reductions in height growth for heavily infected compared to healthy or lightly infected trees in certain southwestern mixed conifer habitat types. Analyses of ten year periodic annual increment for healthy and lightly infected dominant and codominant Douglas-firs indicated there are significant differences in volume growth between several of the habitat types sampled. Heavy dwarf mistletoe infection caused significantly reduced growth in 2 habitat types. In addition, the degree of volume growth reduction for moderately and heavily infected Douglas-firs varied greatly between habitat types.

I. Nicholls, Thomas, Frank Hawksworth and Laura Merrill. North Cent. For. Exp. Stn., 1992 Folwell Ave., St. Paul, MN 55108 and Rocky Mt. For. and Range Exp. Stn., 240 W. Prospect, Ft. Collins, CO. 80526. - Animal vectors of dwarf mistletoe with special reference to *Arceuthobium americanum* in lodgepole pine. The dwarf mistletoes (*Arceuthobium* spp.) cause an annual volume loss of 418 MCF in the U.S. They cause reduction in growth, quality, and seed production and are a major cause of tree mortality. Establishment of infections beyond the normal range of seed expelled from explosive fruits indicates involvement of vectors. The problem is there is little information on the importance of vectors in the life history of dwarf mistletoes. A study on the Fraser Experimental Forest in Colorado during 1982-83

identified 10 bird and 4 mammal species as potential vectors. A total of 626 birds (including retraps = IRT) of 30 species and 300 mammals (IRT) of 4 species were trapped and examined for seed. During a 16-day peak seed-dispersal period in 1982, 22% of the birds (N=55 IRT) and 20% of the mammals (N=80 IRT) had seed. Results show that vectors may be more important in the long distance spread of dwarf mistletoe seeds than originally thought. Important vectors are the gray jay (Perisoreus canadensis), Steller's jay (Cyanocitta stelleri) and the least chipmunk (Eutamias minimus). Radio tracking gray jays proved useful for following their movements between infected and healthy stands of trees.

- J. Nickrent, Daniel L. Department of Botany, Miami University, Oxford, OH 45056. - Infrageneric relationships in Arceuthobium (dwarf mistletoe - Viscaceae). Genetic relationships within 19 New World taxa of Arceuthobium were investigated using starch gel electrophoresis of seed endosperm. Allelic frequency data for 12 polymorphic loci from forty populations of the above taxa were compared using the unweighted pair group cluster analysis of Rogers (1972) and Nei's genetic identity. In comparison to the previously generated phenogram based on morphological, physiological, and ecological data (Hawksworth & Wiens, 1972), some similarities and differences emerge. Two subgeneric taxa (Arceuthobium and Vaginata) are maintained with modifications. A large group (10 taxa) within subg. Vaginata group together at 0.7 percent similarity or

greater and generally represent section Campylopoda. The specific status of component taxa within this group remains questionable and a cladistic investigation is warranted. The affinities of section Minuta (including A. douglasii and A. pusillum) appear to reside with subg. Arceuthobium, not Vaginata. Inclusion of A. divaricatum (pinyon dwarf mistletoe) within sect. Minuta as opposed to sect. Campylopoda is also strongly supported by the allozyme data. A Mexican taxon, A. rubrum, previously placed in a separate series of sect. Campylopoda, groups with A. vaginatum ssp. cryptopodum, A. vaginatum ssp. durangenensis, and A. gillii ssp. gillii all included within sect. Vaginata. This taxon may be transitional between the two sections. Owing to the extreme morphological reduction and apparent overall phenotypic convergence, phylogenetic relationships in this group of parasites has been obscured.

- K. Scharpf, Robert F. Pacific Southwest Forest and Range Experiment Station, Forest Service, U.S. Department of Agriculture, P.O. Box 245, Berkeley, CA 94701. - Host resistance to dwarf mistletoe. With few exceptions, the dwarf mistletoes (Arceuthobium spp.) are host specific. Any one dwarf mistletoe species usually has only one to a few conifer species as primary hosts. Resistance to infection by dwarf mistletoe is shown by only occasional or infrequent infection of coniferous species other than the primary hosts. A few instances are known in which a primary host species was found to be resistant to a

species of dwarf mistletoe. In one study, resistance of some ponderosa pines, (Pinus ponderosa) to infection by A. campylopodum was attributed to the drooping characteristics of the hosts foliage. In another case, different populations of Jeffrey pine, (P. jeffreyi) were found to vary in their resistance to A. campylopodum. Further research is needed, however, to determine mechanisms of resistance and to demonstrate resistance among other dwarf mistletoe-host combinations.

- L. Tinnin, Robert O. Environmental Sciences and Resources/ Biology, Portland State Univ. - Changes in community structure and function resulting from infection by dwarf mistletoe. Dwarf mistletoes cause significant changes in the structure and function of individual lodgepole pine trees. The changes include modified rates of physiological process, such as decreased rates of respiration for infected trees, different structural characteristics of twigs and needles, such as reduced twig and needle mass, and different branch growth patterns associated with witches' broom formation. Since lodgepole pine was the dominant species in the communities studied, the changes in the individual trees due to infection by dwarf mistletoe contributed to differences in the structure and function of the entire community. For example, the infected stands tended to support a greater density of mature trees having smaller diameter and shorter stature, relative to their age, as compared with uninfected stands. These differences suggest a convenient tool to examine

the ecological effects of stress and chronic disturbance on community dynamics.

- M. Tocher, Richard D., Steven M Gustafson and Donald M. Knutson. Biology Dep't. Portland State Univ. - Water metabolism and seedling photosynthesis in dwarf mistletoes. The water loss from aerial shoots of dwarf mistletoes is usually severa times the rates of their coniferous hosts on a surface area basis. Moreover, the parasite transpires at high rates even when the host is water stressed. During the night, when host transpiration is zero, the mistletoe is losing water at about half the rate it displayed at its maximum in the afternoon. The greatest difference in water potential between host and parasite is also seen during the night. Young mistletoe seedlings which germinate in the spring must survive for several months until penetration of the host occurs in the summer. At this stage, they are capable of a limited amount of photosynthesis, although respiration is always several times the rate of CO<sub>2</sub> assimilation. Photosynthetic capacity was estimated by the difference of O<sub>2</sub> uptake in the light and the dark. Light incorporation of <sup>14</sup>CO<sub>2</sub> was about 600 times the amount of fixation in the dark. In 24 h experiments the seedlings incorporated a quarter of the CO<sub>2</sub> available in ambient air but owing to their net CO<sub>2</sub> evolution at all times, their photosynthetic rates cannot be computed. Ninety-eight percent of the <sup>14</sup>C taken up was ethanol soluble, and of this, about 10% was chloroform soluble. The water soluble <sup>14</sup>C was 19% anionic, 22% cationic and 5%

non-ionic. The low chlorophyll contents (0.25 - 0.4 mg/g fresh weight) in ungerminated seeds is compatible with the low rates of photosynthesis observed.

alter the frequency and intensity of subsequent fires. This, in turn, influences the frequency and abundance of dwarf mistletoe.

- N. Zimmerman, G. Thomas and Richard D. Laven. Dep't of Forest and Wood Sciences, Co. State Univ. Ecological inter-relationships of dwarf mistletoe and fire in lodgepole pine forests. Dwarf mistletoe (Arceuthobium americanum Nutt.ex Engelm.) is the most serious disease agent in lodgepole pine (Pinus contorta Dougl.) forests. Fire represents the ecological factor most responsible for the structure and distribution of these forests. Although not clearly understood, the reciprocal relations among fire, mistletoe and lodgepole pine represent a complex of interactions that affect both growth and development of dwarf mistletoe and lodgepole pine, and the frequency and intensity of fire. Periodic occurrence of fire of various intensity levels can have differential effects on dwarf mistletoe throughout its life cycle. Indirect effects of fire, such as smoke and high temperature exposure can occur during reproductive and growth phases, causing either a stimulation or inhibition of parasite development. Such indirect effects may have little or no impact on dwarf mistletoe proliferation. Direct fire effects, including fire-induced host and/or parasite mortality significantly modify dwarf mistletoe populations, or even eradicate this disease from specific areas for various lengths of time. Conversely, dwarf mistletoe-induced changes in lodgepole pine forest structure and fuel accretion can substantially

ADJUSTED TREASURER'S REPORT, THIRTY-FIRST WIFDWC

Balance on hand at close of thirtieth meeting: \$611.58

NOTE: The cost of the twenty-ninth proceedings was removed from this report and shows in the twenty-ninth. The actual cost was \$709 instead of \$708. This resulted in carry-over balance one dollar less than shown in 29th treasurer's report.

Interest paid July 1,1982 through June 30,1983 69.12

Sale of extra proceedings 15.00

Bank debit for misc. Canadian check -3.00

sub total 692.70

Thirty-first WIFDWC statement:

Receipts: Registration \$1860.00  
 Dwarf mistletoe luncheon 150.00  
 (25 people)  
 Root disease luncheon 186.00  
 (31 people)  
 Cruise banquet 1110.00  
 (74 people)  
 Misc. sale -old proceedings 36.00

sub total 3342.00

Expenses: Meeting 2891.07  
 Printing of proceedings 590.00

sub total 3481.07

-139.07

Balance at close of thirty first meeting 553.63

Treasurer's report redone 11/29/84 Ken Russell

TREASURER'S REPORT, THIRTY-SECOND WIFDWC

Balance on hand at close of thirty-first meeting:		\$553.63
Interest paid July 1, 1983 through June 30, 1984		54.12
Sale of extra proceedings by mail from Olympia (4)		37.00
Binding cost for proceedings in historian's file		<u>-43.03</u>
sub total		601.72
Thirty-second WIFDWC statement:		
Receipts: (73 people)	3879.00	
Interest on temporary local acct.	15.62	
sale of old proceedings (6)	<u>60.00</u>	
sub total	3954.62	
Expenses: Meeting	2667.34	
Printing proceedings	<u>723.66</u>	
sub total	3391.00	563.62
Balance at close of thirty-second meeting		1165.34

Continuous account No. 936258 held at:

Washington State Employee's Credit Union  
 PO Box WSECU  
 Olympia, WA 98507

As of July 1, 1984, Uncle Sam will deduct ten percent of earned interest from all deposits to help repay the US debt. The new law requires deposit holders to withhold such and send it to IRS. In the first quarter of our accounting year they deducted \$3.99 - our contribution to keeping the government alive.

This has required a tax number for our account. So far it is not too complicated, and eventually we will get the money back since I told them we were a nonprofit scientific organization. It will show up as returned interest on future reports.

The tax number is 91-1267879.

Official signatures for withdrawing funds from our account as of October 31, 1984 are Ken Russell, Walt Thies and Fields Cobb.

Ken Russell, November 1984

## Projects

Projects are cross-referenced under 11 board category headings. The under listing is numbered by year of inclusion and projects are modified at irregular intervals by some spokesperson, so consequently the list includes projects of benefit to members carried out by non-members, however the whole thing may be out of date. The listing can be found in the 31st Proceedings pp 103-116. Below I have listed the oldest projects which probably reflect the seniority of certain scientists and/or quietness of certain spokespersons. Let's hope that spokespersons in the future will send up-dates to the secretary in order to produce a listing usable by the membership.

- 53-H-1 Testing progeny of resistant pines for susceptibility to white pine blister rust in the Inland Empire (R. Bingham).
- 58-J-1 Deterioration of beetle-killed Engelmann spruce in Colorado (T. Hinds).
- 61-H-1 Streamlining pollination and progeny test methods in breeding for blister rust resistance in western white pine (R. Bingham).
- 62-F-1 Life tables for lodgepole pine and ponderosa pine dwarf mistletoe (F. Hawksworth, T. Hinds).
- 63-G-1 A study of Ophiostomaceae wood staining fungi in North America (R. Davidson).
- 66-D-1 Investigations on the occurrence and control of Fomes annosus (C. Driver).

Projects to be deleted include:

### A. Forest Disease Surveys--General

- 81-A-2 Region-wide surveys to establish impacts of root rots for FIDIS (D. Johnson, E. Sharon).
- 83-A-2 Pest damage surveys in Inland Empire Tree Improvement plantings (O. Dooling, J. Dewey).

### C. Cone, Seed, and Seedling Diseases

- 80-C-4 Pathogenesis of Fusarium on sugar pine at the Medford Nursery (C. Li, W. Thies, E. Nelson).
- 81-C-12 Benomyl and captan residues and biological activities in forest nursery soils (C. Li, E. Nelson).
- 81-C-19 Effect of Rhizobacters on root disease and seedling growth (A. McCain, R. Bega).
- 83-C-4 Fusarium root disease of western white pine (B. James).
- 83-C-5 Nematode population assessment and control at Fantasy Farms Nursery (S. Hagle).

### D. Root and Soil Diseases or Relationships (Including Mycorrhizae)

- 77-D-1 Characterization of zone lines formed on artificial media and in wood by Phellinus weirii (C. Li).
- 79-D-21 Displacement of Phellinus weirii from stumps by the antagonist, Trichoderma viride (E. Nelson, W. Thies).

79-D-22 Chemical control of Phellinus weirii (W. Thies, E. Nelson).

79-D-30 Effect of red alder, cottonwood, and Douglas-fir on nitrogen and microbiological activity in soil (C. Li).

#### E. Foliage Diseases

83-E-2 Distribution and impact of Lophodermium pini and other needle cast fungi in Scots pine Christmas tree plantations in western Montana (S. Hagle and W. Kissinger).

#### F. Stem diseases, Malformations, Witches-Brooms, Dwarf Mistletoes, etc.

78-F-1 Expanded field plot study (into southwest Oregon) of Douglas-fir dwarf mistletoe development in thinned precommercial stands (D. Knutson).

79-F-3 Dwarf mistletoe loss assessment in Douglas-fir, lodgepole pine, and western larch in north Idaho National Forests (O. Dooling).

80-F-1 Dwarf mistletoe loss assessment surveys (D. Johnson, F. Hawksworth).

#### G. Stem Diseases: stains, and Decays

73-G-1 Decay associated with logging-damaged conifers in Oregon and Washington (P. Aho).

73-G-2 Tests of wound dressings on artificial injuries on western hemlock and Sitka spruce (P. Aho).

79-G-3 Decay hazard in advanced regeneration of tolerant conifers in Oregon and Washington (P. Aho).

79-G-4 Decay associated with logging wounds in young-growth white fir and grand fir tops killed by the spruce budworm in the Wenatchee and Okanogan National Forests (P. Aho).

#### H. Stem Diseases; Rusts and Cankers

81-H-2 The effects of comandra blister rust on lodgepole pine: predicting the consequences of silvicultural treatments in rust-infected stands (B. Geils, W. Jacobi).

#### K. Miscellaneous Studies

78-K-2 Reduction in stem volume of grand fir defoliated by western spruce budworm outbreaks in the Payette National Forest, Idaho (G. Ferrell, R. Scharpf).

83-K-5 Vegetative management plan for Armillaria mellea, Phaeolus Schweinitzii, and Endocronartium harnessii (C. Stewart, R. Cates. and V. Applegate).

Projects modified are:

#### A. Forest Disease Surveys--General

71-A-4(84) Appraisal of damage caused by forest pests in British Columbia (R. Alfaro).

71-A-5(84) Forest insect and disease survey (G. A. Van Sickle).

71-A-7(84) Disease sampling in Douglas-fir plantations (W. Bloomberg).

- 71-A-9(84) Forest insect and disease survey in the prairie Provinces, and Northwest Territories (B. Moody, H. Wong).
- 73-A-4(84) Forest disease: diagnostic and taxonomic services and research (J. Hopkins).

G. Stem Diseases: Stains, and Decays

- 73-G-4(84) The role of microorganisms in bark beetle epidemiology (S. Whitney).

New Projects are:

A. Forest Disease Surveys-General

- 84-A-1 Pest Impact Assessment Methodology--Fomes annosus. (Palmer-Bega-Otrosina).

C. Cone, Seed, and Seedling Diseases

- 83-C-7 Western Gall rust, Endocronartium harknessii, inoculation trials on jack pine seedlings to select resistance (Y. Beaubien, K. Knowles, S. Segaran, D. Gillis, G. Falk).
- 84-C-1 The effect of inoculum density of Macrophomina phaseolina on conifer nursery production (McCain--Bega).
- 84-C-2 Evaluations of pathogen-caused mortality of Engelmann spruce seedlings at northern Rocky Mountain nurseries (James and Gilligan).
- 84-C-3 Studies of Fusarium-associated diseases of conifer seedlings at northern Rocky Mountain nurseries (James and Gilligan).

- 84-C-4 Characteristics and identification of Phoma spp. associated with conifer seedling diseases (James).

- 84-C-5 Evaluation of conifer seedling mortality caused by Diplodia pinea in northern Rocky Mountain nurseries (James).

D. Root and Soil Diseases or Relationships (Including Mycorrhizae)

- 83-D-18 Spread of Armillaria mellea in pine plantations (K. Knowles, Y. Beaubien).
- 84-D-1 A case history of root disease development in unmanaged and commercially thinned stands on the Fernan Ranger District (Hagle and others).

F. Stem Diseases, Malformations, Witches-Brooms, Dwarf Mistletoes, etc.

- 83-F-4 Rate of spread, volume loss and management strategies for Arceuthobium americanum on jack pine and Arceuthobium pusillum and white spruce (K. Knowles, Y. Beaubien, D. French, F. Baker).
- 83-F-5 Effect of N-fertilization on growth and development of dwarf mistletoe on red fir. (R.F. Scharpf).
- 83-F-6 Resistance of Jeffrey pines to dwarf mistletoe. (R.F. Scharpf, B. Kinloch and J. Jenkinson).
- 84-F-1 Parasitism of dwarf mistletoe on red fir by brown felt blight. (R.F. Scharpf).

H. Stem Diseases; Rusts and Cankers

83-H-7 Western Gall rust, Endocronartium harnessii, inoculation trials on jack pine seedlings to select resistance (Y. Beaubien, K. Knowles, S. Segaran, D. Gillis, G. Falk).

83-H-8 Evaluation of association between forest tent caterpillar, Malacosoma disstria, defoliation and Hypoxylon canker, Hypoxylon mammatum in trembling aspen (K. Knowles, I. Delbaere).

#### I. Wilt and Blight Diseases

83-I-1 Population dynamics of the native elm bark beetle, Hylurgopinus rufipes, pertaining to the spread of dutch elm disease in Manitoba (I. Delbaere, P. Pinchuk).

#### K. Miscellaneous Studies

00-K-1 Taxonomic studies of forest fungi (A. Funk).

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