PROCEEDINGS OF THE 3rd ANNUAL WESTERN INTERNATIONAL FOREST DISEASE WORK CONFERENCE

Spokane, Washington
December 1955
Proceedings of the 3rd Annual Western International Forest Disease Work Conference

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The Western International Forest Disease Work Conference convened in Spokane, Washington, November 30 through December 2 for the third annual meeting. Originated and designed to advance forest disease research and to integrate the work of forest pathologists in federal, state, and private agencies in western United States and Canada, the 1955 meeting contributed greatly in accomplishing this objective. The agenda, the well prepared reports, and subsequent subject discussions provided first-class opportunities for exchange of ideas, techniques, and procedures. (Secretary's note: It will be only through utmost participation and cooperation that our members will continue to receive the benefits that our Conference does and will provide. The Proceedings as reported herein narrate the 1955 meeting.)

INTRODUCTORY COMMENTS BY THE CHAIRMAN

Introduction of guests and conference delegates.

Gentlemen, it is a pleasure to act as your chairman this year and to welcome you to Spokane and to the third annual meeting of the Western International Forest Disease Work Conference.

It is a pleasure to welcome you because this conference brings together a group of individuals who have many things in common. The principal thing, of course, is our mutual interest in the development and progress of forest disease research, a phase of endeavor that has assumed major importance in the general scheme of forestry activities, particularly in the United States and Canada.

As civil servants, most of us have other interests in common as well. For example, I just heard of a Government plant pathologist back east who started poor 25 years ago and recently retired with a comfortable fortune of $50,000. This was acquired through industry, very stringent economy, conscientious effort, indomitable perseverance—and the death of an uncle who left him $49,990!

The agenda this year has been designed to tie over and provide continuity to the 1954 discussions at Berkeley, California. One item which should be maintained from year to year is this morning's session dealing with new projects, termination of projects, and the presentation of new and modified techniques.

This year we are attempting a more formal approach to our program by having panel speakers contribute prepared papers within specified maximum time limits, and submitting copies for the use of the conference secretary. Panel members do not necessarily have to adhere to their prepared statement word for word, and they are perfectly at liberty to present contribution in their own way within their maximum time limit. It will be interesting on Friday during our business meeting to determine your reaction to this form of agenda.
This year, also, we have assigned the three program committee members as sub-chairmen or moderators for each of the three days of conference. Today's sessions, for example, will be moderated by Phil Thomas, Thursday by Toby Childs, and the Friday morning session by Bob Bourchier.

The joint session was dispensed with for this year not only because of a last-minute clash in schedules with the forest insect work conference, but because enthusiasm and interest in discussing a joint topic was noticeably lacking on the part of both pathologists and entomologists.

In closing these few introductory remarks, gentlemen, I would like to acknowledge the excellent work of your programme committee chairman, Phil Thomas, and his committee of Toby Childs and Bob Bourchier, the work of your secretary, Don Leaphart, and the cooperation we have received from all of you in developing and preparing the schedule for these deliberations. We hope you will find the program both profitable as well as enjoyable and that you will let loose with no hold barred, so to speak, in the discussion periods that will follow the panel contributions.

V. J. NORDIN
Chairman
AGENDA

Wednesday, November 30 (G. P. Thomas, Moderator)

1. Notification of new projects, review of changes in or terminations of projects, and notification of new or modified techniques.
   (See Appendices I, II, and III, respectively)

2. Dwarfmistletoe Control

   RESEARCH NEEDED TO PERFECT DWARFMISTLETOE CONTROL

   By R. J. Bourchier

   I obviously can't tell specifically what research is needed to perfect control of dwarfmistletoe. However, I am going to toss out a few ideas for discussion on avenues of research that might pay off in better control. I don't think that it is likely that we will ever have perfect control in the strict sense but procedures will have to be developed that will be reasonably adequate for various situations.

   I have arranged things under two headings: 1) fundamental information needed for and application to research in all types of control. 2) interim extensive research more akin to the trial and error method of empirical research.

   Under the heading of fundamental, I think the importance of research on the anatomy and physiology of the host parasite relationship should be stressed. This avenue of attack should reveal the weak spot in the relationship that would be most susceptible to enhance tree resistance and/or to reduce mistletoe vigor. Knowledge of the nutrition, hormone and enzyme relations in penetration, spread, and reproduction of the parasite should point to the easiest methods of effecting direct control.

   For example, information on translocation would be forthcoming from such research and would apply directly to determining the best method to apply chemical control substances, by injection, spray, or by some other means. Further, information on the length of time an endophytic system could endure without aerial shoots would ensue. This, of course, has direct application to the timing of sanitation operations of all kinds, either chemical or mechanical. Basic studies on the anatomy and physiology would throw some light on the possibility of host resistance and possible methods of its action. Questions on the method, rate and direction of penetration, and spread in the host would be clarified. Once it is known how these things occur we will be in a better position to try and find a way to control dwarfmistletoes.

   The taxonomy of the dwarfmistletoes and the question of host specificity of the species needs further clarification. This is fundamental research that has immediate application to control. Silvicultural practices to convert stands to species believed to be non-susceptible
might need revision in view of host transfers. Also, the application of knowledge in the basic fields depends on good identification and a sound taxonomy.

While the above problems are being prosecuted as relatively long range projects, it would seem common sense to persist in our more or less trial and error search for control methods so long as these efforts are kept in proper proportion. I have a few suggestions to make for the purpose of stimulating discussion on chemical control. How about testing for a substance that would inhibit germination of the mistletoe seed? By spraying annually with such a compound in a residual form at germination time, would it be possible to protect regeneration for say 5-7 years from mistletoe-infected seed trees? I visualize this as a short term business to protect regeneration until seed trees or overstory have been removed. Regeneration is easily sprayed compared to large trees which, in many cases are not worth cleansing. The future crop is a different matter, however, and this method could also be used to provide isolation strips around infected patches. If a residual spray of sufficient duration was found, it could be used in conjunction with sanitation cuttings. How about increasing host resistance with injectants rather than to kill the mistletoe? Perhaps the host could be given an opportunity to overcome the parasite or, alternatively, to resist infection. Another way would thus be provided for making isolation strips.

Parasitic fungi should be assessed carefully in their role as possible control agents. Just how much control do they effect in nature? Are they worth giving a helping hand? A careful search should be made for parasitic fungi both here and in other continents. There is the interesting question of mistletoe susceptibility to sprays if the mistletoe has been attacked previously by fungi. The possible effect of a combination of two or more control agents should be explored.

The question of host resistance can be clarified, in part at least, by the extensive approach. A search for apparently resistant trees should be made and inoculation experiments carried out to see whether resistance is real. The actual mechanism of resistance should be clarified by intensive research on physiology.

Further experiments on cutting and silvicultural practices that are designed to control dwarfmistletoe are needed in all areas and under different conditions of host and parasite. Silvicultural methods of control have been the best of all control techniques developed thus far and should be developed further. It is quite likely they will be the only methods applicable to some areas.

Better survey techniques are needed to determine where control is justified. A line cruise method with closely spaced lines to locate patches of mistletoe, is being used to advantage in high-value areas in Alberta. I wonder what are the possibilities of aerial surveying? I have doubts about its feasibility in lodgepole pine forests, although it may have good possibilities in jack pine forests.

Finally, the utilization of mistletoe-infected trees should be investigated. If such material could be used it would make intensive sanitation cutting procedures possible. For example, in Alberta we have a plug mill which produces small wooden plugs that are used by the railways to fill spike holes in railroad ties that are being reclaimed for
In conclusion, I stress the need for basic research in the anatomy and physiology of host-parasite relationships and, at the same time, urge the continuation of empirical research in chemical, biological, and silvicultural control, and various combinations of them.

Considerations Bearing on Silvicultural Control of Dwarfmistletoe of Ponderosa Pine

By Lewis F. Roth

The following comments are based on recent observations of dwarfmistletoe in the ponderosa pine forests of Oregon along the east slope of the Cascade Mountains. While the pine forests differ somewhat to north, east, and south, it is probable that many of the dwarfmistletoe relationships applying in central Oregon will occur elsewhere in the northwest.

Various conditions of cover exist, but the greatest land area is occupied by essentially uncut saw timber and by cut-over land from which nearly the entire merchantable volume was removed at harvest several decades ago. Much of the latter type is now moderately well-stocked with poles and saplings which probably represent advanced regeneration released at the time of logging. The virgin forest area comprises a variety of large patches of even-aged timber, intermixed at random with extensive areas of all-aged forest. The even-aged stands which occur in a wide range of age classes, clearly became established after fire. The all-aged stands probably arose in a similar manner many years ago, but now are so long over-mature that progressive opening of the canopy and freedom from serious fires has enabled the establishment of an all-aged forest as small groups of trees have come up from time to time in openings in the original stand.

The existence of a dwarfmistletoe problem in these forests is only slowly coming to be recognized, even though J. R. Weir nearly forty years ago noted the prevalence of the pest and the damage it caused.

Dwarfmistletoe is distributed throughout the area in widely scattered, irregular patches ranging roughly from one to 160 acres in area. These patches are usually larger and more numerous as the slope steepens up to about forty per cent. Less than twenty per cent of the total pine type is infested, and of this amount less than half is infested to the point that damage is readily apparent. Mistletoe incidence is very low in the young stands where, for the most part, infection is restricted to small areas of regeneration surrounding widely scattered infested overstory trees. These trees survived the fire which ultimately lead to the establishment of the young stand. Enlargement of these infections is very slow, because of the limited ability of the parasite to spread laterally through the crowns of trees of uniform height.

In the all-aged forest mistletoe is wide-spread and abundant. Overstory trees are conspicuously broomed; intermediates are weak, distorted and of poor quality. Regeneration is frequently worthless,
and infestations appear to be actively spreading. The condition of dwarf-mistletoe on the heavily cut-over lands is intermediate between the types described.

From these preliminary remarks we see that mistletoe infestation creates a special situation. The acreage involved probably is not great enough to call for modification of over-all management practices of the region; however, the infested areas will require special attention, if they are to be raised toward their potential productivity. The very complexity of the situation indicates that a single, generally applicable procedure is not to be expected. Many considerations will bear on determination of appropriate control treatments.

Evaluation Problems

Accurate means of mistletoe evaluation are a primary requisite to silvicultural control. Reliable permanent records of the location and extent of infested areas are necessary for both planning and executing a control program. Severity of infection is an important consideration also. Severity is usual thought of in terms of existing losses; but for silvicultural purposes it must be interpreted in terms of threatened damage; that is, degree of infestation in the young stock and total infectiousness.

Determination of how much, where and how bad must be followed by decision as to whether or not the values lost to mistletoe warrant control. Will the expected improvement in lightly infested stands justify treatment, or still more important, will badly infested stands bear the high cost of treatment?

If control is elected, the next evaluation problem is the establishment of mistletoe tolerance levels. Such levels, combined with an effective method of classifying infection, will provide the basis for locating boundaries between treated and untreated areas and between areas receiving different treatments. They will also facilitate decisions as to type and severity of treatment within the control areas.

Finally, measurement of the effectiveness of control work calls for standards that will enable accurate comparisons of treated and untreated stands.

At the present time, we appear to lack evaluation methods that will enable us to make any of the above decisions other than location and extent of infection.

Development of effective methods of measuring damage presents a number of problems. Both quantitative and qualitative values must be weighed; that is, how badly is the present stand reduced in productivity and how infectious is it? Appearances are often misleading, and damage may sometimes be greatest when it is least apparent.

The mistletoe-infested stand, as we observe it, represents the cumulative effect of many years of parasitism. There is relatively little outright killing, so we may safely assume that no single season's
activity will measurably alter the situation. Past damage, therefore, is of relatively little importance, except as it may affect harvest planning. To be sure the inventory is reduced, but this may just as well have resulted from poor site or any other of a number of factors.

From the standpoint of silvicultural control, however, past damage is of primary importance as a basis for predicting future losses. To what extent is mistletoe going to reduce future productivity of stands of different ages, different composition and different degrees of infection? Considered in this light, the degree of infectiousness of all members of the stand becomes an important management consideration, ranking along with the degree of individual infection of future crop trees. Both must be kept constantly in mind when considering control by silvicultural methods.

Treatment Objectives

Logically the objectives of a silvicultural control program should have been discussed before we considered evaluation problems; however, determination of objectives is so dependent on an appreciation of the problems involved in evaluation that I have delayed "objectives" to this point.

Dwarf mistletoe, in my judgement, is a menace to pine forestry on all infested sites. It is not a great and immediate threat, but it does constitute a slowly increasing menace. Rate of lateral spread is impossible to predict, but intensification in infested areas seems almost certain. The pest is now causing intermediate damage and probably is being held at this level of destruction by fire which from time to time has burned out old infestations. With effective fire control mistletoe damage may be expected to increase.

Our central objective should be an increase in productivity of lands bearing mistletoe-infested stands; however, whether such an increase is accomplished or not, we must not allow losses to grow worse, and certainly we are called upon to accomplish the degree of control that in the past has resulted from fire. To do this, some type of stand treatment appears necessary. What should these treatments accomplish?

Two general alternatives are available to us. The first is to exterminate the pest within the infested area, and then to establish a new stand. The second is to manage the infested areas on a special basis and attempt by prolonged stand treatments to reduce losses to a tolerable minimum.

With this decision made, what stands and what components of the stands should receive treatment? What treatments are appropriate and in what order should they be applied? Do we remove the overstory and then prune the understory, or do we destroy the infested understory and later remove the overstory? Can treatments not intended for extermination purposes be one-time affairs, or must we plan for repeated follow-up? Should we aim to manage mistletoe-infested areas on an all-aged basis or as even-aged units?

I am unable to answer these questions, but I will risk two observations.
The following viewpoint may seem extreme, but in my judgement extermination will be the ultimate silvicultural control requirement. Extermination may one day be forced upon us, and in the long run, I believe this method will be the least expensive and most effective procedure. Stand destruction may not be required or not be desirable for a full rotation or more. The correct time of treatment will be determined by stand characteristics and severity of infestation. The need for such destruction may be retarded by improvement in other methods, by availability of abundant cheap labor to do stand improvement work or by other factors.

The critical question in my mind is not whether there is need for stand destruction and a new start, but rather when should it be undertaken and how much temporary stand improvement and control work should be done in infested stands in the interim? In certain types of stands, large poles for example, this question might be simply answered. In other stands the decision will not be easily made. In any event it appears reasonable that only those stand treatments should be applied that will contribute to the maximum timber recovery at the least cost up to the time that it becomes desirable to remove the entire stand and start over.

With these convictions about the final desirability of stand destruction and a new start, at least the question of even-aged versus all-aged management of mistletoe infections is answered in my own mind. While it may be desirable to manage infested stands on an all-aged basis for some time to come, there will be an ultimate shift to an even-aged unit basis.

The above comments do not imply that mistletoe infestation will become so bad and productivity so low that we must then start over. On the contrary, the clean sweep probably should come at the peak of productivity of the infested stand in order that the higher timber volume might carry the cost or even provide a profit.

**Time of Treatment**

In light of our present deficient knowledge of the pest, any changes in forest management planning based on the mistletoe problem might well await further knowledge of mistletoe behavior, of severity of infection and of damage caused. The elimination of worthless, infested regeneration is an exception to this recommendation.

Scheduling of mistletoe treatments will be influenced by control objectives, by severity of infection and by the nature of the infected stand. Accessibility and economic factors will also affect treatment scheduling.

The fact that the longevity of mistletoe-infested trees is not seriously threatened, should exclude them as a major item in sanitation-salvage; however, if trees are needed, in addition to "high risk" trees and salvage, to build up the specified volume of the sanitation-salvage cut, then highly infectious mistletoe trees are appropriate for marking.

Again, it is necessary that we know more about mistletoe damage and behavior before establishing cutting priorities for infested stands. This is especially true for mature timber where infection is relatively light. An exception to this recommendation is found in heavily infested
mature timber with the regeneration riddled by mistletoe. In most cases stands of this description should be harvested on a clear-cut basis at the first opportunity. Cutting priority probably also should be raised for any stands in which damage is definitely increasing in merchantable timber. Lightly infested stands that appear more or less stabilized should be able to await their normal turn in the harvest program, at which time "clean-up" work can be accomplished.

In mature timber the disease condition of the understory should be an important consideration in deciding the time and method of harvesting the overstory. Except for occasional highly infectious trees removed during sanitation-salvage, no harvest cutting should be made without analysis of the disease condition of the understory and without a definite plan for treatment of remaining trees. Treatment of the understory might be included in the terms of the timber sale or might be paid for from sale proceeds. Delay in planning could deprive the manager of these opportunities. Unfortunately, we are unable to state with confidence which understory treatments are most appropriate in each case.

The place of partial cutting in mistletoe-infested stands of this region also is poorly known. Release by partial cutting may increase the vigor of reserve trees which, if these trees are infested, will increase the vigor of the mistletoe. Increased vigor will increase infectiousness resulting in serious infestation of the understory. On the other hand, partial cutting may be desirable where infestation is very light and the allowable cut sufficiently great to guarantee removal of all infested overstory trees. Exceedingly careful marking will be required in an operation of this nature.

Because of limitations in our basic knowledge, it is almost impossible to make valid silvicultural control recommendations for the patches of mistletoe-infested young-growth scatter through the all-aged forest. The fact that these young-growth stands are frequently heavily infested and that they represent a very important age class for the region makes the mistletoe problem occurring in them an especially important one for the forest manager.

What is to be done for the many acres of infested regeneration in the cut-over? With this question answered, when should the work be undertaken?

Conclusion

Though mistletoe losses are sometimes difficult to demonstrate, the need for silvicultural treatment of certain types of mistletoe-infested stands seems apparent. Lack of factual knowledge of how and where to start is a primary obstacle to progress. This deficiency is apparent and restricting at almost every step of planning for silvicultural control. Much research is needed before we can progress with silvicultural treatment on a basis of sound understanding rather than speculation.

Basic knowledge of mistletoe development is especially needed. The host and parasite appear to be in closely balanced equilibrium,
and a shift for either better or worse may result from a small change in the environment. The best example of this relationship is the positive correlation between host vigor on one hand and parasite vigor and seed production on the other. I believe also that light, topography and relative position in the stand affect the equilibrium as no doubt do other factors. Obviously, a great deal of additional research is needed. Then, with a fuller knowledge of disease response to changes in environment and in stand condition, treatment can be undertaken on a logical basis. The needed research information should come as much from carefully planned, empirical stand modification experiments as from an inductive approach. Research of both types should be encouraged.

INTEGRATING DWARFMISTLETOE CONTROL INTO FOREST MANAGEMENT WITH SPECIFIC REFERENCE TO PONDEROSA PINE OF THE SOUTHWEST

By George S. Meagher

Introduction

I chose to limit this paper to ponderosa pine of the southwest for two reasons. First, because this is the only area and species where I have worked directly with the problem; and second, because the vital question there is not "Should dwarfmistletoe be integrated into forest management?" so much as it is "How far should we go in integrating control into forest management?" Though we still have a lot to learn about dwarfmistletoe in the Southwest, evidence at hand amply demonstrates that it's a bad actor in that region, but a bad actor that is subject to silvicultural control.

In an attempt to further fence in the topic, I'll assume that I'm timber staffman for a northern Arizona national forest which contains a half million acres of commercial forest land, mainly ponderosa pine.

I'll further assume that Hawksworth and Andrews have recently completed a reconnaissance survey of dwarfmistletoe on our forest. It showed, among other things, that half of our stands are infected to some degree and that one-quarter are heavily infected. Their report further demonstrated that mortality is twice as high in infected as in non-infected stands. The forest supervisor is now convinced that we will have to give dwarfmistletoe a lot more attention than we have in the past. As a first step, he has asked me to review research and experience on dwarfmistletoe and outline practical control measures that can and should be undertaken as a part of our regular forest management job.

\[1\] Stands were classed as heavily infected when over two-thirds of trees in predominant size class are infected; as moderately infected if one-third to two-thirds of trees in predominant size class are infected; and as lightly infected if less than one-third of tree in predominant size class are infected.
Forest Conditions

We recognize two forest types on our commercial forest land. Pure ponderosa pine covers 400,000 acres or four-fifths of the total. Mixed pine -- in which Douglas-fir, white fir, and limber pine occur in mixture with ponderosa pine -- accounts for the remaining 100,000 acres (Table 1). The mixed type is found in a zone of slightly higher elevation and rainfall where more ample moisture favors the more tolerant species. Even in the mixed type, however, ponderosa pine is the most abundant species and makes up a majority of the stand volume. Generally, our ponderosa pine occurs in even-aged groups, but each group usually occupies a small area, often only a fraction of an acre. In the mixed-pine type, the more tolerant Douglas-fir limber pine and white fir -- though often sparse in the overstory -- are abundant in the understory regeneration.

Commercial logging has been under way on our forest since the turn of the century, and about half of the area in both forest types has now been cut over (Table 1). Harvesting has all been based on tree selection, but the per cent of volume removed has varied all the way from 80 per cent in early operations to as little as 10 to 15 per cent in recent sanitation-salvage type cuttings.

By area, 25 per cent of our stands are heavily infected with dwarf-mistletoe, 13 per cent moderately infected, 12 per cent lightly infected, and 50 per cent are free of dwarf-mistletoe (Table 1). This distribution is fairly uniform throughout all forest types and condition classes.

Current Forest Practices

The present scheme of management calls for light cuts at frequent intervals in both virgin and cutover stands. This adaption of the selection silvicultural system tends to develop stands with a wide variety of age and size classes represented on areas as small as 2 or 3 acres. In recent years, one of the principal objectives has been to quickly cover the remaining virgin stands with a very light cut and concurrently complete the development of a permanent network of utilisation roads.

Our current market is mainly for sawlogs, and we can sell any tree 12 inches or larger in diameter that has a 12-foot log to an 8-inch top. We also have a relatively new but limited market for pulpwood that takes stems down to a diameter of 6 inches.

Funds collected through K-V deposits have largely been used for the pruning of selected crop trees of pole size on the sale areas. Pruning operations have been limited to areas that are fairly free from dwarf-mistletoe infection.

So far, we have not attempted to control dwarf-mistletoe, although infection is one of a number of factors considered in judging relative vigor, quality, and risk in marking trees to cut or leave.
Basis for Silvicultural Control

Research by Gill\(^2\)/ and Hawksworth\(^3\) has provided the main basis for silvicultural control. Very briefly, the key facts are:

1. Principal spread results from the mature seed of one female plant landing and germinating on a young twig in the same or an adjoining tree.

2. Main spread of infection from an infected overstory tree to nearby seedlings, saplings, or poles is limited to a distance of about 60 feet from the base of the overstory tree.

3. Within a one-storied or even-aged stand, the spread to new trees is much more limited and slower.

4. Infection in a stand can be reduced to a very low point by systematically removing infected trees of all size classes.

5. In some cases, a tree may be rid of dwarfmistletoe by pruning off infected limbs.

6. From the time a dwarfmistletoe seed alights on a pine stem, at least 26 months elapse before the first shoot buds appear; at least 33 months before flower-bearing shoots are produced; and 48 months before the first crop of fruits are matured. Development of the plant is commonly much slower.

Recommendations

Management objectives

My Number 1 recommendation is that our forest adopt, as one of our long-time goals, the reduction of dwarfmistletoe infection to a point where it will have a negligible influence on amount and quality of timber yields. A reasonable time for accomplishing this long-time goal would be the main conversion period -- the next 80 to 100 years.

Our immediate objective will be to move as fast as we can in this direction with the funds, manpower, and facilities currently available to us for inventories, management planning, timber sale administration, planting, and stand-improvement work.


Forest inventory

The newly completed reconnaissance survey shows in a general way which parts of our forest are free of infection and which portions are lightly, moderately, or heavily infected. This is a good beginning, but this information will need to be intensified greatly to provide the detail we will eventually need for effective silvicultural control. My guess is that we will need reliable maps that show the pattern and degree of infection for areas as small as 5 or 10 acres.

Perhaps some of this information can be obtained through additional pest-control surveys. More intensive dwarfmistletoe surveys might be fully justified because the information will have fairly permanent value. With dwarfmistletoe, the pattern and degree of infection can be expected to remain fairly uniform for many years. With pests such as bark beetles or needleblight, in contrast, the pattern can be expected to change rapidly from year to year, and information from a single survey has only temporary value. The possibility of using aerial surveys along with ground examination to speed up dwarfmistletoe surveys also should be further explored.

In addition to whatever outside help can be mustered, we will need to collect as much information on dwarfmistletoe as we can during our regular forest inventory, timber sale, and stand-improvement jobs. Since extent of infection may influence future growth and yield as much or more than number of stems and board-foot volume, the collection of dwarfmistletoe information should definitely be integrated into our periodic forest inventories.

One underlying need in all these survey efforts will be the development of a classification for rating degree of infection for both trees and stands that is easy to apply and yet meaningful in terms of silvicultural control.

Management planning

The growth and mortality records currently used in our calculations of allowable cut were obtained from stands where dwarfmistletoe is much lighter than it is over our entire forest. There's a good possibility that our mortality estimates are low and our figures on net growth and allowable cut overly optimistic. In any event, a critical appraisal of these calculations will need to be made at an early date.

Our rotation age and length of cutting cycle may also have to be scaled down for stands with medium or heavy infection. Certainly growth and financial maturity culminate much sooner in infected trees and stands. And since mortality losses are twice as high in infected stands, the volume taken out in sanitation-salvage cuttings may need to be stepped up materially.

Our current policy of applying the selection silvicultural system to all types and condition classes will also have to be critically examined. Silvicultural control of dwarfmistletoe can be integrated into forest management most effectively and inexpensively when a clear-
cutting system of silviculture is applied to an even-aged stand. Clear-cutting makes it possible to completely eliminate the overstory infection in one harvest cutting. Existing regeneration can then either be cleaned up through thinning and pruning or destroyed and replaced with uninfected seedlings through planting or seeding. Under the selection system, in contrast, only part of the overstory is removed in any one harvest, and the complete elimination of overstory infection is much more difficult. Obviously, unless overstory infections are eliminated, re-infection from one tree generation to the next is almost inevitable. Thus, silvicultural control is feasible under the selection system where infections are light or scattered, but becomes much more difficult and expensive where stands are moderately infected. In heavily infected stands, silvicultural control will call for drastic departures from selection cutting as normally applied.

Practices in the pure pine type

In our pure pine forests, regeneration presents a chronic problem because widespread crops of pine seedlings come in at unpredictable and very infrequent intervals. So far, we haven't been able to get restocking where and when we need it through either natural means or through planting and seeding. The selection system of silviculture offers definite advantages in meeting this situation. Even-aged silviculture, however, will be very difficult to apply in our pure pine stands until we have learned to overcome this regeneration hurdle.

For the time being, therefore, I recommend that we continue to harvest our pure pine stands on a selection basis and that we concentrate initial dwarfmistletoe control efforts in the lightly infected stands where our chances for success are most favorable. This will mean no change in current practices on the 200,000 acres that are not infected, or on the 150,000 acres that are heavily or moderately infected. For the 50,000 acres that are lightly infected, the following practices are recommended:

1. In all commercial harvests, mark for removal all merchantable trees containing active crown infections in addition to those that would normally be taken out. This includes both sawtimber and pulpwood sales.

2. Schedule timber sales so that pulpwood is either removed concurrently with the sawtimber or during the subsequent 5 years.

3. During commercial sales, map in place the extent of infection in the nonmerchantable portions of the stand so they can be readily located for later cleanup operations.

4. Postpone stand improvement until 5 years after harvesting is completed.

5. During the stand-improvement operation, provide for a complete cleanup of remaining dwarfmistletoe infections in addition to the usual pruning of crop trees. Some trees will be adapted to cleanup through pruning. Most infected trees, however, will need to be eliminated from the stand through cutting or poisoning.
6. To catch latent infections, repeat cleanup operations in infected portions of the stand about 10 years after logging.

The strategy here will be to first remove the overstory infections through sawtimber sales, then clean up the large pole groups through pulpwood sales, and finally to systematically eliminate infections in the small pole, seedling, and sapling size trees through at least two sanitation operations. The direct cost of the dwarfmistletoe control in such a program is not known, but I am enough of an optimist to believe that in lightly infected stands it would not exceed $25 to $30 per acre -- comparable to the cost of planting.

Some infections will, of course, escape detection the first time over so that some additional cleanup on a much smaller scale will be needed in the succeeding cutting cycle.

One special stand condition deserves early control action whenever it is encountered. This is the stand where a good crop of pine seedlings has recently become established under a moderately or heavily infected overstory. New seedlings will probably remain fairly free of infection during the first 5 to 10 years of development; and silvicultural control can be achieved quickly and inexpensively by clearcutting the overstory and releasing the newly established but uninfected seedlings. Post logging sanitation measures, if needed, could be carried out at minimum cost. Opportunities for this type of treatment should not be overlooked in the pure pine type even though it involves a drastic departure from the usual light selection cutting.

A notable omission in the initial plan of action for the pure pine type is the lack of a concrete control program for the 150,000 acres that are moderately or heavily infected. Control action in these portions of the forest has purposely been postponed because we are currently unprepared to proceed with confidence.

Use of clearcutting, except in special cases, is precluded by the difficulty of re-establishing a new stand. Control under partial cutting is theoretically possible, but the cost would be high, and it would be exceedingly difficult to eliminate dwarfmistletoe infections and at the same time maintain an adequate stocking of trees to assure continued forest production at a reasonable level. While we're easing into control work, however, we hope research on dwarfmistletoe and regeneration can be accelerated so that improved methods will be available when the time comes to aggressively attack the problem in stands moderately or heavily infected. Damage appraisal and economic studies will also be needed to provide better answers then we have now to the question: "How much are we justified in spending on dwarfmistletoe control?"

Practices in the mixed-pine type

In the mixed-pine type, regeneration comes in more frequently, and we have had considerably more success with plantations. This provides much greater flexibility in silvicultural system and method of cutting. In the portions of the mixed-pine type that are not infected, no change in current forest practices will be required. In the 50,000 acres that are infected, however, I'm going to recommend that we change from partial
cutting to clearcutting in all our final harvest operations. Clear-cutting will be applied in a patchwise pattern, and we will aim toward blocks 5 to 10 acres in size. In selecting areas to clearcut, priority will be given to stands that are heavily infected. The following practices are recommended:

1. Locate cutting units so that the heaviest concentrations of infected mature trees are included within the unit.

2. Where possible, locate boundaries of cutting unit in portions of the stand where infection is less severe.

3. Remove all merchantable trees within the unit during the saw-timber sale.

4. If possible, also market all trees of a size merchantable for pulpwood.

5. During the course of the logging, mark and cut all merchantable trees with 60 feet of the unit boundaries to help guard against reinfection along the borders of the clear-cut unit.

6. After logging and slash disposal are completed, provide for the establishment of a clean stand of regeneration through the least expensive of the following alternatives:

   a. Cleanup of advance understory regeneration through thinning and pruning in two properly timed sanitation operations.

   b. Destroy existing nonmerchantable understory trees through tractor operations or broadcast burning; then plant or seed ponderosa pine.

Another procedure that might merit trial would be to first prescribe burn to destroy existing understory trees; then harvest the main overstory but retain sufficient uninfected seed trees to provide natural restocking; and finally to harvest the seed trees after regeneration is established.

In addition to facilitating dwarfmistletoe control, clearcutting will also help to control species composition in the regeneration, that is, to favor ponderosa pine over its more tolerant but less valuable associates.

Where commercial thinnings are made in young, mixed-pine stands (and the final harvest will be postponed for many years), no attempt will be made to eliminate or control dwarfmistletoe during the intermediate harvest. Efforts at actual control will be integrated only with the final harvest when the entire stand will be removed and replaced with dwarfmistletoe free regeneration. Of course, if dwarfmistletoe infection is severe, a young stand will reach financial maturity at a much earlier age than if non-infected or only lightly infected. In some cases, therefore, a final harvest cutting might be justified in a badly riddled stand that has only attained pulpwood size.
Rehabilitation of burns

We occasionally have severe fires in both our pure- and mixed-pine types that cause wholesale destruction of the forest vegetation over sizable areas.

In the pure-pine type, the restocking of these burns is exceedingly difficult. Natural regeneration must be encouraged by excluding from the salvage sale the few scattered trees that survived the fire. They will be needed to provide a source of seed. Planting or seeding is usually also needed to augment what natural seedlings are obtained. Once satisfactory regeneration is established, any infected trees that remain in the overstory should be harvested promptly to safeguard the new stand against dwarfmistletoe.

Following severe fires in the mixed-pine type, we rely mainly on planting or seeding for regeneration. In this case, all infected trees should, if possible, be marked for cutting during the post-fire salvage operation.

Efforts to develop strains of ponderosa pine that are resistant to dwarfmistletoe infection should be strengthened and accelerated. If resistant strains can be developed, they should, of course, be drawn on as rapidly as possible for all seeding and planting operations. If resistant stock was available for use, control work would be greatly simplified. For one thing, overstory infections could be practically ignored.

Training

Probably the Number 1 factor that will determine our progress in dwarfmistletoe control will be the degree to which our own personnel at all levels understand the nature and extent of our dwarfmistletoe problem, the life history of the plant, the basis for silvicultural control, and the purpose and strategy of our control efforts. An immediate need will be a series of training courses both in the office and the field to thoroughly acquaint our men with all phases of the problem. This will need to be augmented with continued on-the-ground training. Certainly binoculars will have to become as common a piece of field-going equipment as diameter tapes are now. And our men will have to be trained to use them for appraising and mapping degree of infection and in carrying out all phases of dwarfmistletoe control. In return for this training effort, we can anticipate that our men will make dwarfmistletoe control more effective and less costly.

Table 1. Commercial forest land on the Northern Arizona National Forest, by forest type, condition, and degree of dwarfmistletoe infection (thousands of acres)

<table>
<thead>
<tr>
<th>Degree of dwarfmistletoe infection</th>
<th>Pure pine</th>
<th>Mixed pine</th>
</tr>
</thead>
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<tr>
<td>Virgin</td>
<td>Cutover</td>
<td>Virgin</td>
</tr>
<tr>
<td>Heavy</td>
<td>50</td>
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<td>100</td>
<td>25</td>
</tr>
<tr>
<td>Total</td>
<td>200</td>
<td>55</td>
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SUMMARY OF CHEMICALS TESTED FOR CONTROLLING WESTERN SPECIES OF DWARFMISTLETOE (Arceuthobium spp.)

By Lake S. Gill

Origin and Development of the Report

At the Second Western International Forest Disease Work Conference held at Berkeley, California, December 2 - 4, 1954, a special session was called to consider the question of chemical control for dwarf mistletoe. Here it was agreed that a summary of the experiments to date would be helpful in developing a coordinated research program in the future. Accordingly, those members of the conference who have been actively engaged in chemical control studies agreed to pool their information and delegated the writer to summarize it.

A form was developed by the group on which reasonably uniform data were given on each test. Considering that the experiments of each investigator had been designed and undertaken independently, the forms received from the contributors could be used only for broad interpretations. In the summary table (Appendix II) the results of each test have been classified with respect to effect on both host and parasite. It should be pointed out that a "test" constitutes a single investigator's treatment with one concentration of a particular formation. In some cases one to several bunches of dwarf mistletoe shoots were sprayed, even drenched, an effort being made to avoid the host foliage; in others, entire trees, foliage and dwarf mistletoe shoots were treated, while in others the spray was applied as a mist to all trees on a small plot. Obviously, therefore, the damage appraisals given in Appendix II are not necessarily comparable from one experimental series to another. The "trees killed" column is particularly unreliable in the case of spray treatments. The investigator who followed the most consistent experimental pattern was Mielke (tests designed by "L"). In his case, all sprays were applied to small plots of lodgepole pine infected with A. americanum.

Despite its limitations the data in Appendix II should be useful in evaluating past work and in planning future experiments. To those who are contemplating new studies and who may wish to benefit from the experience outlined in this report it is suggested that they correspond directly with the particular contributor or contributors whose work may seem to have a bearing on his own problem. Names and addresses of the contributors are given in Appendix I, along with the symbols used to designate their tests in Appendix II and elsewhere in this report.

A criticism draft of the report was circulated to the contributing experimenters and to Dr. Offord for review. Many helpful suggestions and some corrections were made as a result. One major change stemming from this review has been the addition of an annotated bibliography as Appendix IV.

The trade names and manufacturers of the numbered formulations shown in Appendix II are given in Appendix III. Addresses of the manufacturers have been omitted, since these are readily available in Entoma and similar directories dealing with agricultural chemicals.
Results

There were 260 tests reported (Appendix II). Of these, 209 described single sprays, 32 resprays after a 1-year interval, and 19 injections. One or more concentrations of 59 separate formulations, mixtures, or trade products are represented. In most cases the active ingredients were dissolved in water alone; although oil emulsions were used in 28 tests, detergents were added in 13, small amounts of boric acid were added in 25, small amount of methyl alcohol in 7, an unidentified "sticker" in 8, while in 2 tests both a detergent and methyl alcohol were used. There was no apparent effect from these additions except that oil emulsions were generally harmful to the foliage of Pinus contorta, the only species on which they were used.

None of the spray formulations met the ideal requirement of killing the dwarfmistletoe plants without damaging the host. Several killed the dwarfmistletoe shoots but failed to harm the absorbing system so that new shoots formed rather rapidly. Chloro IPC and maleic hydrazide appeared to be most consistently damaging to dwarfmistletoe shoots and at the same time relatively harmless to the host. In three tests (149, 89, 98)\(^1\) endothal sprays appear to have delayed resprouting of A. americana for three years with no observed damage to the host (P. contorta). In two tests esters of 2,4-D (C10) and 2,4,5-T (A118) showed some promise of killing the absorbing system of the parasite but caused severe damage to the host. Other tests with the last two compounds were inconsistent. Two tests with 2,2-dichloro-propionic acid (P7a and 7b) were harmless to both host and dwarfmistletoe shoots after 2 1/2 months and will require further observation to determine their effectiveness. One test with maleic hydrazide (A127) appeared to cause stunting of the dwarfmistletoe shoots. Another mixture of maleic hydrazide with an amine salt of 2,4-D (A132) is suspected of causing abnormal dwarfmistletoe fruits. Neither of the latter two tests damaged the host. Sodium chlorate (C13, 14, 15) is the only formulation that damaged the host without apparently harming the dwarfmistletoe shoots.

The following sprays were repeated on part of the treated infections after an interval of 1 year: 2,4-D amine salts, 2,4-D esters, 2,4,5-T amine salts, 2,4,5-T esters, MCP, chloro IPC, and a mixture of maleic hydrazide plus 2,4-D amine salts. One test with maleic hydrazide plus 2,4-D amine mixture gave some promise of having reduced resprouting (A131).

Five materials were injected into ponderosa pines infected with A. vaginatum with the following results: Boric acid at the rate of .022 oz. per inch of d.b.h. was ineffective for 11 months but an examination during the 14th month indicated that most of the dwarfmistletoe shoots in the lower crown of injected trees had died. It definitely warrants further experimentation. Amine salts of 2,4-D alone and in mixture of maleic hydrazide gave inconsistent results, but hold some promise as a differential toxin where light dosages are used (A182, 183, 185, 186); dosages of amine salts alone at the rate of 0.075 oz. per inch of d.b.h. killed the trees (A27, 28, 29). Arsenic tricarbazide killed a single test tree when applied at the rate of 0.005 oz. per inch of d.b.h. Copper sulfate in dosages above 0.05 oz. per inch of d.b.h. was lethal to trees but in dosages of 0.04 oz. or less the trees survived and some killing of the parasite was observed in

\(^1\) Location and number of test (See Appendix I and III).
the vicinity of the injection points. Injections of magnesium sulfate were apparently harmless to both host and parasite.

APPENDIX I

List of Contributing Agencies and Investigators

Division of Forest Biology - Canadian Department of Agriculture

Laboratory of Forest Pathology
Calgary, Alberta (C) *

Spray tests of 1952-55 on A. americanum on P. contorta reported by R. J. Bourchier.

Forest Service, U. S. Department of Agriculture

California Forest and Range Experiment Station
Berkeley, California (B)

Spray tests of 1928-29 on A. campylopodum on P. ponderosa reported by W. W. Wagener. Spray tests of 1945 on A. campylopodum on Abies concolor, P. ponderosa, P. jeffreyi, and P. lambertiana reported by J. W. Kimmey.

Intermountain Forest and Range Experiment Station
Ogden, Utah (L)

Spray tests of 1952-55 on A. americanum on P. contorta reported by J. L. Mielke. These tests were made in cooperation with the Targhee National Forest and the American Chemical Paint Company.

Pacific Northwest Forest and Range Experiment Station
Portland, Oregon (P)

Spray tests of 1952-55 on A. campylopodum on P. ponderosa reported by Ernest Wright.

Rocky Mountain Forest and Range Experiment Station
Fort Collins, Colorado (A)

Spray, respray and injection tests of 1952-55 on A. vaginatum on P. ponderosa reported by S. R. Andrews and F. G. Hawksworth. All tests were made in New Mexico; in the case of other units reporting, the tests were made in the Province or State indicated by the headquarters address.

* Letters in parentheses are used to show the origin of tests mentioned in the text and tables of this report.
<table>
<thead>
<tr>
<th>Active Ingredient</th>
<th>No.</th>
<th>None</th>
<th>Kill</th>
<th>None, Light, Heavy, Killed</th>
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<td>2,4-Dichlorophenoxyacetic acid</td>
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<td>8</td>
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<td>2,4-D acid salts</td>
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<td>1</td>
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<td>2,4-D esters</td>
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<td>2,4,5-T ester</td>
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<td></td>
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<td>2-methyl 4-chlorophenoxyacetic acid (MCPP)</td>
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<td>2,3,5,6-Tetrachlorophenol</td>
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<td>Arsenic trichloride</td>
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<td>Sodium arsenite</td>
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<td>Mixtures/</td>
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<td>2,4-D + maleic hydrazide</td>
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1/S = spray; R = re-spray; I = Injection.
2/See Appendix I for location symbols.
3/Percent composition not given on reports. See Appendix III for closest approximation.
4/VM shoots in lower crown of injected tree dead after 14 months. —2,3.
APPENDIX III

Key to trade names of formulations.

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<tr>
<th>Formulation</th>
<th>Trade Name</th>
<th>Manufacturer</th>
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<td>1</td>
<td>638 Weedone</td>
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<tr>
<td>2</td>
<td>LW4 Weedone</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>LFN 165</td>
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</tr>
<tr>
<td>4</td>
<td>#472</td>
<td></td>
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<tr>
<td>5</td>
<td>2,4-D IN 6065</td>
<td>E. I. du Pont de Nemours &amp; Company</td>
</tr>
<tr>
<td>6</td>
<td>none</td>
<td>U. S. Department of Agriculture</td>
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<tr>
<td>7</td>
<td>#909</td>
<td>American Chemical Paint Company</td>
</tr>
<tr>
<td>8</td>
<td>#646</td>
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<tr>
<td>9</td>
<td>Chipman 2,4-D Amine</td>
<td>Chipman Chemicals Ltd. (*Chipman Chemical Co., Inc?)</td>
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<td>10</td>
<td>2,4-Dow Weed Killer</td>
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<td>11</td>
<td>Tufo-40</td>
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<td>Esteron 10-10</td>
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<td>16</td>
<td>Ester Weed Killer</td>
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<td>2,4-D Butyl ester</td>
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<td>18</td>
<td>Chipman 2,4-D ester</td>
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<td>19</td>
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APPENDIX III - continued

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* Manufacturer's name as listed in the 10th edition of Entoma when at variance with the name given by the experimenter.

APPENDIX IV

An Annotated Bibliography on Chemical Control of Loranthaceous Parasites


Injections of Eucalyptus with 2,4-D to control Loranthus. Minimum dosage required in fall, maximum in spring.


Shoots of A. campylopodum f. typicum on P. ponderosa killed but resprouted after spraying with esters of 2,4-D and 2,4,5-T. Generally trees survived.


Experiments with injections to control Loranthus on Eucalyptus. Copper sulfate best of 18 inorganic substances tested but mistletoe kill is incomplete and host damage often severe. Best is 2,4-D for maximum damage to Loranthus and minimum to host; may take 2 years to kill Loranthus. Effective dosage varies with season and square of the d.b.h.; more needed in spring than in autumn.

Spray tests with \textit{A. americanum} on \textit{P. contorta} using MCP, 2,4-D, and potassium chlorate.


Experiments with Phoradendron flavescens on cultivated walnuts using sprays of 2,4-D and 2,4,5-T compounds during dormant period of host. Successful kill of mistletoe without damage to host. Mistletoe continued to die for 2-year period after spraying. Plans more experiments.


Original paper for work reported under anonymous 1954 (Aust. Jour. Sci.).


Preliminary trials with 2,4-D sprays give promise of controlling \textit{Loranthus} on Eucalyptus.


Sprays for controlling \textit{Phrygilanthus} and \textit{Loranthus} on Eucalyptus. Hormex and methoxone at 5,000 p.p.m. most effective. Sodium chlorate damaged both mistletoe and host.


Discusses mistletoe problem and gives instructions for using sprays for control of \textit{Loranthus} on Eucalyptus. Sodium salt of 2,4-D, 0.5\% plus sticker and spreader, applied in spring just before or after rain for best effects; autumn applications fairly satisfactory. Spray mistletoe bunches with short bursts—no need to drench. May take entire season for full effect, i. e., 90\% kill of mistletoe.


Control of \textit{Loranthus} on Dalbergia by injecting small doses of copper sulfate and Feroxone.
Thursday, December 1 (T. W. Childs, Moderator)

1. Damage Appraisal

DAMAGE APPRAISAL IN IMMATURE STANDS

By D. C. Buckland

It is not too difficult to appraise immediate losses in an immature stand at any one time, but it is very difficult to forecast the influence of the damage on a stand at harvest age or forecast the influence of all pathological factors on a stand until harvest age. To date very little work has been done in damage appraisal in the Northwest, such work having been deferred in favor of more objective studies. Now that forest management is the order of the day, however, the management officer is without any means of determining what the influence of various diseases will be on the yield of any given tract of land.

There is a great tendency among foresters to distrust estimates of current damage or predictions of future damage by entomologists and pathologists. This distrust stems largely from our inability to come up with results which are sufficiently representative for wide application and from our inability to present our findings in terms and units of measure which are amenable to practical application by the forester: Frequently the samples have been too small or too local to form a basis for a good estimate, or predictions have been based on too pessimistic an understanding of the ability of nature to recuperate. In many cases too, the estimates have been based on board-foot loss per acre alone, the most easily computed figure, without regard for the distribution of remaining stems, the influence of the disease on crown class distribution, or some other factor, frequently difficult to measure.

In the Northwest we are still far from being able to appraise or predict damage caused by root diseases, foliage diseases, or mistletoes, to say nothing of cankers and rusts of pine, including the much worked-over white pine blister rust.

One of the very knotty problems in damage appraisal is encountered in studies of root rot caused by Poria weirii. It has been the practice to work out losses on a per-acre basis and the results of such estimations appeared in one annual report containing summations of disease and growth and yield of Douglas-fir. It was interesting to note that the annual loss expected from Poria weirii was exactly equal to the annual loss expected for maintaining normal stocking. A forester might come to the conclusion from these results that the root rot was a beneficial rather than a destructive agency as it appeared to thin the stand to maintain normal stocking. The difficult factor to measure is the influence of stocking and its long
term effect. The Cowichan Lake Experimental Forest is riddled with Poria weirii, yet foresters have mentioned that they did not feel the disease had an appreciable effect on the final yield in the area. Twenty years ago the centers of infection looked very bad but now they do not seem particularly serious as the crown canopy has almost closed and the uneven distribution of stems is not so apparent. The disease is having a serious influence on the stand, however, as many of the trees that were marked for final crop have gone out, leaving trees of lower dominance and leaving small openings in the 55-year-old stand. Thus estimates of damage must take into account the loss of dominant trees and the uneven distribution of stems rather than base findings on simple annual loss per acre figures.

Foliage diseases will be one of the most difficult diseases for which to work out a method of damage appraisal. They apparently do not cause measurable loss of increment unless they are very severe. Where Christmas trees are involved, foliage is a prime asset and damage can be readily appraised. In the case of many of our pine plantations needle diseases are chronic and definitely reduce the increment markedly, but it is difficult to assess how much damage is caused by such diseases and how much is the result of the choice of the site for the plantation. In natural stands the damage caused by an occasional epidemic which takes a toll on increment may be assessed with some degree of accuracy. The presence of a chronic foliage disease in a portion of the stand poses a more difficult problem, however. To some degree this disease will continue to reduce the crown class of affected trees, and such trees will be the first to drop out in what may be considered natural thinning. Appraisal can end in a lot of headaches.

In the opinion of many foresters, estimations of damage caused by dwarf-mistletoe has been exaggerated by forest pathologists. Where active logging is taking place mistletoe is rarely of major importance. Nothing can be done about mistletoe in a mature stand -- the method of harvesting the crop and the influence of this method on the regeneration are the important factors. An appraisal of mature timber badly infected with mistletoe should be compared to an appraisal of undamaged trees so that the difference, representing the loss from mistletoe, can be shown as an indication of the importance of proper harvesting. Further, the added risk of the inability of infected trees to recover from insect attack must be brought out.

The average report on decay of mature and overmature stands has resulted in a gross misunderstanding of decay and its potential damage in young growth. Most decay summations computed from studies in mature and overmature stands indicate that decay is of no significance in young growth. This, of course, would appear to be true for any stand at any particular age after maturity, since the residual trees in a stand at any given age are those which have escaped the ravages of root and butt rots, etc. The importance of basal fire scars, the amount of heat needed to bring about entrance for decay, and the effect of logging injury on residual trees need study to provide a basis on which the importance of decay may be predicted in mismanaged stands.
In summing up these rather general remarks it seems that the most important aspect of appraisal of damage is to learn how to do it. It would seem that the entire strength of forest pathology lies in its ability to prove to the forester that diseases are worth noting. If a disease turns large areas of trees red or causes the falling out of a large percentage of the stock, then the forester is duly convinced and interested in what the pathologist has to say. Usually he is much put out by the fact that it is rare that the forest pathologist can come out with any figures to tell him what the influence of this disease will be on the final crop value of the area. It is noteworthy that pathologists are well known for their ability to run research projects and investigations to learn all about the disease, but are also well known for their inability to come up with any feasible controls or reasonable indications as to how important the disease is to the troubled forester. To bring the standing of the forest pathologist up to a par with the forest fire protection officer, as far as usefulness to the forester is concerned, means that we must put much more effort into working out methods of appraising damage without the panic type of propaganda— if we can't prove in dollars and cents or in board-feet that a disease should be given some attention, then we should not talk about it. If we have some good solid, well-based estimates that the forester can understand, we don't need to advertise it and its importance, the forester will do it for us.

APPRAISAL OF THE DAMAGE CAUSED BY WHITE PINE BLISTER RUST
TO WESTERN WHITE PINE AND SUGAR PINE STANDS

By D. R. Miller

There are many reasons for making damage appraisals and there are various approaches to the "how" of making them. The general objectives and techniques of disease survey will probably be covered by others; hence this report will be confined to problems of making an appraisal of the damage caused by white pine blister rust in California and Oregon.

There are several reasons why a blister rust damage appraisal might be undertaken. They are: to determine the extent and intensity of a newly located infection center, to gather information on rust damage when considering areas for new control units, to keep informed on the general spread of the rust, to determine whether it is economical to remove cankers from young crop trees, to further our knowledge of rust behavior, and to determine the effectiveness of control practices for any particular stand. The intensity or degree of accuracy of this damage appraisal depends upon the use to be made of the data. If a general survey is being made the accuracy need not be as great as when the future disposition of a control unit is at stake. And of course the accuracy of a damage appraisal on study plots should be of the highest order.
The damage appraisals for blister rust can be divided into two general categories, namely: those for control purposes and those for study purposes. The standard of control, used in blister rust control work, varies from area to area and generally becomes less rigid as one moves southward from Oregon into California. To state this in a different way, we now believe that we can safely leave more ribes live stem per acre in the central Sierra Nevada Mountains than we can in southern Oregon. The evidence now available indicates that such a practice will hold pine damage to a uniform and tolerable minimum throughout the control units. These variations of control standards are based upon differences of rust hazards that exist between control areas. Areas that possess similar degrees of rust hazard are termed as a rust hazard zone. Four such zones are recognized in control work. Each hazard zone carries its own standard of control. The difficulty of applying this work method is in identifying the boundaries of the rust hazard zones on the ground.

Because the standard of control varies so widely within these zones it is important to make a damage appraisal, at given intervals, inside those control units where the rust is known to be present. The reason for making such an appraisal is to determine the effectiveness of the protective treatment that was applied to any particular area. If the disease is building up, then the question of "How rapidly is the intensification occurring?" must be answered. If the buildup is small and the stocking is good, the damage to the ultimate volume to be harvested may be negligible. However, if the buildup of the rust is rapid or if the stocking is the minimum that will justify protection, then corrective action must be taken immediately.

In control units having a minimum of white pine present or in areas having a well-stocked stand of pine which supports heavy blister rust infection, an accurate damage appraisal must be made. In these cases the margin of uninfected trees may be so small that an error in the appraisal could cause an area of insufficient pine to be retained for further treatment. Conversely, an area supporting ample pine to justify protection costs could be eliminated from further treatment because of error in the damage appraisal. On the other hand, in an insufficiently stocked stand of young trees, if the appraisal shows that the rust has been controlled, the owner might wish to increase his stocking by planting and thus retain the area within the control unit.

The reasons for making damage appraisals outside control units are to keep up with the general spread and development of the rust and to have advance information when areas for new control units are being considered. In many cases the information on hand after these general appraisals has been enough to indicate the necessity of an intensive appraisal before other surveys were made.
The reasons for making damage appraisals for scientific purposes is to
further our knowledge of the rust's behavior under a wide variety of con-
ditions.

Damage appraisals inside a control unit are usually concerned with only
one tree-height group at a time. Generally there is only one height
group present within a single stand or at least one height group predomi-
nates. If two or more height groups are present, as sometimes occurs with
sugar pine, the aggressiveness of the rust usually determines which height
group will receive the greatest attention. The more active the rust the
higher in the tree's crown it becomes established. For example, if both
reproduction and pole size trees are present in a strongly rust active
area, the reproduction is likely to be so heavily infected that few non-
diseased crop trees will be found and the survey must be made in the
poles to determine whether or not enough sound trees remain to warrant
protection. On the same area, if the rust is less active, infection
will likely be confined to the reproduction class and the actual survey
work will be performed almost entirely within this group.

The examination of young trees up to about 25 feet in height, although
slow, is a comparatively simple process. Trees of pole size are much
more difficult to examine. Also, the accuracy of such examinations de-
creases as the height increases. The accuracy of examining young mature
trees is very low unless the trees are either climbed or felled, or un-
less the rust has been present for many years, in which case the damage
is usually readily apparent. In actual practice, damage appraisals are
seldom made in young mature stands of sugar pine. First, there has been
little damage to trees of this size in southern Oregon and California.
This lack of damage may be due to (1) the length of time needed to damage
a large tree after it has become infected, (2) the distance of the crown
from the source of inoculum, (3) adverse weather conditions for this type
of infection in this region, or (4) the fact that the rust has been present
in this region for only about 25 years.

Generally damage appraisals are confined to the reproduction class as this
size is most susceptible to injury. In addition it is the beginning of a
future crop of pine and is the size class in which control must be estab-
lished immediately after it appears. Once control is established in the
younger stand it is rather easily maintained through the remainder of its
rotation. Under these conditions there should be little need for much dam-
age appraisal work in the older stands that have been in a sanitary status
since their beginning.

The type of information needed for the damage appraisal determines the kind
of survey used to gather that information. For example, to keep informed
on the spread of rust from year to year as well as to gather some infor-
mation on the rate of intensification under natural conditions, the ribes
and pine at 150 to 200 favorable rust spots scattered throughout southern
Oregon and northern California are examined each summer and fall. The
ribes and white pine growing on a small area at each of the rust spots are examined quite thoroughly and it is felt that this is adequate to give the general over-all picture of the rust's behavior. Observations during the past several years have borne out this belief.

When disease information is to be applied to smaller areas or where a detailed record of the status of the disease is needed an intensive type of survey is made. Here is an example of one type of problem and the way it is met. An area within a blister rust control unit in southern Oregon has had the ribes suppressed to a very low level through protective treatments. The blister rust staffman desires to know whether he has achieved control of the rust or whether new cankers are still appearing. If new cankers are present he then wishes to know their pattern of location, their ages and their number. He may also desire to know how many uninfected crop trees per acre remain on the area. These questions have been answered satisfactorily by examining and taking data on a given number of trees from each of a given sized transect along a continuous strip. This information was usually taken in conjunction with other work and the strips were from 2 to 5 chains apart. The appraisal men kept a sharp lookout for young cankers whose origin was more recent than the date of the last protective treatment. When an incipient canker was found the crew stopped and made a thorough search for other cankers as well as for the ribes bush that caused the damage.

The strip survey system with either continuous plots or plots at a given interval has also been used to give the amount and distribution of the rust in both proposed and established units. Usually this type of appraisal is made in conjunction with other work, such as a pine appraisal if it is in a proposed control unit or with some type of ribes population survey if work is being done within a control unit. When work is being performed within a proposed control unit, the combination damage and pine appraisal should be made before any other preparatory work is done toward giving protective treatment to the pine on the area. In other words, the net pine values should be ascertained to determine whether control treatment is justified. Strips, as used, are from 1/4 to 1/2 chain wide and are spaced from 5 to 10 chains apart. Generally the strips are run perpendicular to the main drainages.

The randomized-plot type of survey has been used with very good results on large disease survey plots when a fair percentage (10 percent or better) of the area is being sampled. In using this type of survey the area was broken down into 2½-acre subareas and the proper number of randomized plots were taken within each subarea. The location of these sample plots was determined through the use of playing cards. The randomly selected plots could have a common corner but not a common side.

When a less accurate sampling on these same disease study plots was needed a systematic type of plot survey was used. The sampling plots were placed in a predetermined pattern within each subarea. The percentage of area sampled by this system was usually 5 percent or less.
Permanent plots are also used for damage appraisal purposes. These plots were originally designed to measure the effectiveness of control treatment received by a particular area. The plots were established within an existing pine infection center which had been found inside control areas. Most of the plots are one acre in area and subdivided into square-chain units. Since this type of plot is few in number each had to support enough pine to offer a good target for infection. The presence of ribes bushes was not necessary but some bushes were found on nearly all plots. The pine population on these plots is examined at 3- to 5-year intervals. The plot is thoroughly searched for ribes bushes before and after each protective treatment. The permanent plot survey differs from other damage appraisal surveys in that complete records are kept of each tree, so that its progress through the years can be followed.

The pine and canker data taken on all plot-type surveys have thus far been recorded in code and transferred to International Business Machine cards for summarization. I have a specimen of this card here for those of you who might wish to see it. With these data, along with the results of micromitic studies being made at blister rust infection centers by others, it is hoped we can, before too many more years elapse, provide control supervisors with accurate means of forecasts of the damage to be expected under a given set of conditions.

**DAMAGE APPRAISAL: A PROBLEM IN MULTIPLE USE FORESTRY EXEMPLIFIED BY THE COMANDRA BLISTER RUST IN THE INTERMOUNTAIN REGION**

By J. L. Mielke

Several species of pines are hosts of the Comandra blister rust (*Cronartium comandraceae*). This discussion will deal mainly with one of these hosts, viz., lodgepole pine (*Pinus contorta*). It is the most abundant pine species in the Rocky Mountain Region.

False or bastard toadflax (*Comandra umbellata*) is the only known alternate host plant of the rust in the region. It is rated by range managers as a worthless forage plant for livestock and big game animals. Floras describe the habitat of the toadflax in various ways as follows: "in dry ground", "dry gravelly places", "dry rocky soils, which often have a low water content", "on dry sandy slopes and banks", etc. Toadflax does not seem to tolerate a great deal of competition with other plants.

Observations conducted during the past few years have revealed that heavily diseased lodgepole stands are common in the Intermountain Region. Infection areas from about one to three sections in size are common and far larger ones exist. In one stand it was estimated that 98% of the trees were infected. Estimates made in some other stands range between 65% and 85%.
Severely diseased lodgepole pine stands have been noted to date on seven National Forests as follows: Shoshone, Teton, Bridger, Caribou, Cache, Targhee and Sawtooth. In addition, the rust is widely distributed in Teton National Park and present also in parts of Yellowstone.

Lodgepole pine has been known to be an occasional host of the Comandra blister rust for a long time. On the other hand, there are no records in the literature of the fungus causing extensive damage to the tree. All evidence to date indicates that the epiphytotic is of relatively recent origin. In most of the heavily diseased stands it appears that intensification of the rust started about 15 or 20 years ago, possibly a little longer. In no case is this period regarded as much longer than about 25 years. This is substantiated by observations made by the older forest officers, i.e., those who have spent most of their careers in the general region. According to them there were no damaged lodgepole pine stands present 20 or 25 years ago in those areas resembling those common today.

What has caused this native fungus, of no previous economic importance, to become so destructive only recently? Moisture is needed for the infection for both the pine and alternate host plant. There is no evidence of a climatic change over the region that would aid in accounting for the epiphytotic. Instead, weather records show the present cycle or period to be one of decreased precipitation. If weather was the responsible factor, it would seem logical to assume that there would have been favorable conditions for abundant intensification of the fungus at various times in the past. Since there is no evidence of past damage to the pine the possibility of changed climate as a cause of the present behavior of the organism would seem not to be the answer.

Although no factual data exist to support it, the only plausible answer appears to be that there has been a marked increase in the abundance of toadflax. Range management officers familiar with the problem all share this opinion. It is well known, that over most of the region, the range lands have been severely overgrazed and abused. As a result of this destruction of much of the original ground cover, the environment of areas has been changed. Often the topsoil is badly eroded and sometimes gone, runoff of water is increased and infiltration decreased, soil temperatures are higher, etc. This changed environment has created a habitat required by the toadflax. It is a plant not found in a good cover of grasses and appears in the succession when other plants die out. There is no question but what there is much more habitat area favorable for toadflax growth and spread today than there was 50 years ago. Furthermore, every heavy lodgepole pine infection area known today is in association with overgrazed lands. Since this is the case the problem becomes much involved.

According to our present knowledge of the Comandra blister rust the following factors must be given consideration in a damage appraisal.
Commercial value of the lodgepole pine
At the present time many of the diseased stands have relatively
little or no commercial value because of their inaccessibility and
limited demand for the stumpage. This situation, however, has
started to change. Whose job is it to predict the future value of
a stand of lodgepole that has no commercial value at the present
time? The forester is not interested if he is not selling the
timber.

Rust-killed timber
As the stand is thinned out and eventually killed by the fungus there
occurs an increase in grasses and other forage plants. This increased
forage is of but a temporary nature, however, because in time the
dead timber falls into a tangle of jackstraws, thus practically closing
the area to entry by livestock and big game animals. Furthermore, the
dead timber is a fire hazard.

Recreation
Public use of our national forests and national parks increases an-
nually. In Teton Park, for example, the most common tree species is
lodgepole pine. The rust is widespread in the Park and intensifying.
Dead trees along roads and on campgrounds are hazardous and have to
be removed. This is costly. On the Teton Forest summer homesites
and campground areas are being reduced in value as the fungus kills
out the pines. Can a monetary value be placed on public recreation
in a case of this kind?

Watershed values
Denuded watersheds do not provide a good supply of clean water for
domestic, industrial and other uses. Reservoirs lose their values
when they become silted in. The recreational factor also enters here.
Scoured-out streams and muddy lakes do not provide good fishing,
swimming and boating.

Domestic livestock
Livestock owners want more domestic animals on the range and contend
that there are present too many big game animals. The latter compete
with the livestock for food and this situation is regarded by the
livestock owner as not compatible with his best interests. The range
is badly overgrazed and there is not adequate forage for the animals
now present.

Big game animals
Sportsmen contend that the livestock numbers should be reduced, thus
permitting more food for the big game animals and increases in their
numbers through improvement of the range.
(7) Commercial aspects
The merchants want more sportsmen and tourists because it is big business with them. The resort and lodge owners, dude ranches, big game guides, packers, and others are also out for more business.

(8) Degree of infection in the pine stand
Because of the incubation period of the rust in pines and the difficulty of seeing young infections in the crowns of large trees growing in a dense stand it would be extremely difficult and costly to ascertain, within a reasonable degree of accuracy, the amount of infection present. We have a concrete example of that. From a single wave of infection of this rust, that occurred in ponderosa and Jeffrey pines over 40 years ago in California, killing of mature timber is still taking place. Literally tens of thousands of trees have died to date and losses are continuing. When Dr. J. S. Boyce studied this infection area over 40 years ago the largest infected tree noted by him was about 10 inches d.b.h. The crowns of the mature trees could not be examined for young infections. One could make an appraisal of the volume of timber killed up to a given date. But, of what value is that if a stand is eventually doomed?

(9) Distance of spread from toadflax to pines
Intensive studies have not yet been conducted on the Comandra rust and the distance of spread to lodgepole pine from the alternate host is not yet well established. Present evidence strongly indicates that infection to pines may occur over distances of 2 or 3 miles, perhaps farther. Lack of adequate knowledge about the pathogen thus hampers any damage appraisal.

(10) Porcupines
These rodents have concentrated in all areas of heavy pine infection to feed on the diseased bark. They also cause damage to uninfected trees. The damage probably is greater in extent than is normally the case in a healthy stand because of the increased numbers of the animals on an area. Also, it would be necessary to determine, at the time of appraisal, if the animals were at a high, low or some intermediate stage in their cyclic populations.

(11) Bark beetles
Will bark beetles invade pine stands containing numerous trees weakened by the rust, build up populations there that invade surrounding healthy stands, and thus add another factor to the problem. The answer is not yet known.

(12) Control of the pathogen
As yet no practical control measures are known for this rust. A pine stand in which the fungus is present and intensifying could therefore be regarded as eventually doomed. Thus, at least one phase of the appraisal would be simplified.
What procedure should be followed in making an appraisal of losses in a case of this kind? According to Webster's Dictionary, appraise means to set a value on or to estimate the amount of a loss. With a problem as the one exemplified here by the Comandra blister rust, what has been lost or destroyed off which to make an estimate? Are only the trees on the area to be considered? If so, that would be relatively easy because the timber manager should know the stumpage value of the timber. This I would regard as but the minimum loss, however.

What about the other values and factors that enter into this multiple use problem? Are they to be disregarded entirely? If not, then who is responsible for making the appraisals on watershed, recreation, range and other losses? A total of all the losses involved I would regard as the maximum appraisal. I doubt, however, if such an inclusive appraisal would meet with general acceptance because, in my opinion, it simply could not be made without the aid of a crystal ball. On the other hand, what is the difference fundamentally between a fungus destroying a stand of timber and livestock destroying a stand of grass by overgrazing? The end result is the same in that the plants in either case are gone. Who ever heard of a range manager making a damage appraisal of an overgrazed or destroyed range? Instead, to my knowledge, he prepares the soil, plants grass seed and fences the area. An attempt is then made to properly manage the range so as to perpetuate it in good condition.

How can the problem be solved? Too often the forester on the job feels that a fungus epidemic is not his problem, but belongs to the forest pathologist. I have frequently been asked, "Why don't you spray and thus control the pest?" In most of our forestry schools forest pathology is taught by a plant pathologist who does not have any background at all in practical forest management. The student therefore does not learn that forest pathology is an integral part of forest practice. He is not aware of the relationship of environment to disease epidemics. According to Dr. J. S. Boyce, most epidemics of native pathogens arise when a host is weakened by some unfavorable condition. The epidemics do not "just happen". There is always a basic reason but sometimes the reason may be impossible to determine.

Few foresters on the job seem to know that conditions in natural stands point strongly to the fact that there is no factor more important in relation to disease than tree vigor. Stands on good sites are generally not damaged significantly by native diseases, but those on poor sites often suffer severely. Boyce states: "The relation of disease to lack of vigor may be so constant that the activity of a pathogen can be used as a sure indicator of unfavorable growing conditions of the host."

These are some of the fundamentals that the pathologist must teach the forester on the job. To accomplish this, one of the things he must do is to get into the woods with the forester. It is the pathologist's job to see that the forester understands the principles of disease control and
loss reduction. The forester must learn that if he is responsible for the changed environment of a site as the result of overgrazing, or some other cause, it is not the pathologist's job to correct the situation by restoring his range or make loss appraisals for him. I believe it is the forester's responsibility to see to it that practical forest pathology is taught in the forestry schools. When that is done the complexities and interrelationships in damage appraisal should be better understood and appreciated. Multiple use forestry, or wildland management as it is sometimes termed, presents many problems that are seldom if ever encountered in a woodlot.

METHODS FOR APPRAISING DWARFMISTLETOE DAMAGE IN SOUTHWEST

By S. R. Andrews (read by Frank Hawksworth)

Like many other native forest pathogens, the dwarfmistletoes cause an endemic disease that does not invariably result in the death of infected trees. Somewhat to the chagrin of the pathologists, even casual visitors in Southwestern forests hasten to report dwarfmistletoe on mature and overmature ponderosa pines that have reached sawlog proportions in spite of the presence of the parasite for most of their lives. Consequently, control measures that involve the destruction of infected, but not obviously declining or deformed individuals, sometimes appear more damaging than the disease itself. Therefore, to be of practical significance appraisals must not only determine the magnitude of the immediate problem, they must also compare the ultimate natural damage from dwarfmistletoe with the costs of and damage from control operations. General adoption of a program for the control of dwarfmistletoe in the Southwest cannot be anticipated until the results of damage appraisals of the latter type are available, no matter how thoroughly convinced the pathologists may be.

Until recently it was assumed that Korstian and Long's data on the effect of dwarfmistletoe on radial growth and Pearson's figures on growth reduction and mortality were convincing enough evidence of the damage caused in Southwestern ponderosa pines. Recent experience, however, indicates that although the results are generally accepted, they fall short of providing justification for attempting all-out control above the pilot plant level.

According to our present concepts in the Southwest, dwarfmistletoe damage may be broken down into two categories. The first is reduction in productivity under which would be placed growth reduction, mortality which in some cases may lead to replacement by inferior species, and deformation resulting in log and lumber degrade. The second is increase in hazard under which would be included predisposition to drought, insect attacks, fire damage, and other disease agencies.

Current efforts to evaluate these elements in damage are preliminary, the major concern being to develop shortcuts that will provide some of the necessary information until tentative results of the long-time plot studies.
can be procured. Growth reduction resulting from dwarfmistletoe has been studied in two ways. First, a comparison was made of the sawtimber volumes in infected and uninfected stands as determined in the Mescalero-Apache Reservation Survey. Results were inconclusive, largely because the survey was not designed with this objective in mind, but also because dwarfmistletoe infection is usually light in low volume "fringe" stands in the ponderosa pine type. Second, comparisons are being made of the radial growth in infected (rated according to severity of infection) and uninfected trees. This method holds considerable promise but has one major obstacle in that a satisfactory method has not been developed for rating infected trees with respect to severity and length of time the disease has been present. Once this problem has been solved, it is possible that growth reduction can be converted to volume and area bases for use in appraisals. Limited observations have also been made on the Mescalero-Apache Reservation to determine to what extent direct control in heavily infected sapling and pole stands has reduced stocking and the predominant age and sizes of trees—a significant aspect of any control operation.

Estimates of mortality from dwarfmistletoe have been developed by comparisons between infected and uninfected stands. These comparisons have been made in conjunction with the Mescalero-Apache Reservation Survey and in plot studies in the control area on the South Rim of the Grand Canyon. The criterion for periodic mortality apparently is somewhat conservative, but is satisfactory for comparative purposes. As a final step growth reduction and mortality must be considered together.

In connection with the establishment of the Wing Mountain Dwarfmistletoe Plots on the Ft. Valley Experimental Forest at Flagstaff, Arizona, in 1939, an attempt was made to determine the effect of dwarfmistletoe brooms on log quality, comparing the grade of butt logs with broomy branches with the same logs if dwarfmistletoe infection had not caused excessive branch growth. The use of photographs of the logs proved unsatisfactory and further study will require considerable thought and should be undertaken in cooperation with the Forest Products Laboratory.

As yet no steps have been taken to evaluate increase in hazard, but this element will enter into the composite damage that will be determined in the major long-time plot studies. For the present there undoubtedly should be joint studies with Forest Insect Research on the relationship between dwarfmistletoe and bark beetle attacks in both ponderosa pine and Douglas-fir.

The plot studies eventually will provide the information needed to undertake adequate appraisals because in most cases they provide comparisons of various intensities of control with current timber sale practices or natural conditions. The principal studies of this type are the Wing Mountain Unit Dwarfmistletoe Plots, the Mistletoe Reduction Study at Fort Valley (Division of Timber Management of the Rocky Mountain Forest and
Range Experiment Station, assisted by Division of Forest Disease Research, and a number of permanent sample plots on the Grand Canyon National Park and Mescalero-Apache Reservation. The major problem, however, is developing reliable information for immediate use to demonstrate the urgency for aggressive action.

GENERAL REMARKS ON DAMAGE APPRAISAL

By George S. Meagher

Of all the various aspects of tree disease problems, probably no phase is more complicated or challenging than that of damage appraisal. In these brief remarks, all I will attempt to do is mention a few features of damage appraisal that seem to merit consideration.

There is apparently room for wide latitude in scope, methodology, and relative accuracy of appraisals depending on the type of disease organism, kind and continuity of resulting damage, nature and relative cost of control measures, and use to be made of information developed in the appraisal. The three rather distinct kinds of appraisal mentioned below are indicative of the wide variation that exists, but they by no means represent a complete classification:

(1) A very general appraisal such as we make in reconnaissance surveys of a disease or group of related diseases represents one level. Main interest is usually to determine the general extent and pattern of infection and whether probable damage is serious, moderate, or negligible. Results may be used by administrators and pest-action committees for determining relative priority of proposed control programs, by researchers for rating relative importance of alternative research projects, and probably by the local forest manager to help decide whether a certain disease demands attention, can be ignored, or bears watchful waiting. Usually precision required and amount of detail needed are not great. Essentials include an objective rather than an alarmist approach, a sound method of sampling, and a straightforward procedure in analysis and reporting.

(2) An appraisal of a recurrent disease that may flare up and cause considerable kill at unpredictable intervals but that is not subject to control represents a second level. Interest here may center on determining location and volume of killed timber and on estimates of the additional losses to be expected during the current flareup. This information coupled with knowledge of rate of deterioration of killed timber will be used by the forest manager in determining the feasibility of salvage and in scheduling the locale and timing of salvage operations. Greater precision and more detail will be needed than in the general reconnaissance outlined above. Here precise knowledge of the local situation will provide a direct basis for local policy and management decisions.
(3) A third level that represents a much more complicated problem is the economic appraisal that may be required for a disease that will cause continuing damage if unchecked, but one for which practical control measures have been worked out. In this case the forest manager needs to determine for a specific forest area if control should be undertaken and at what level if alternative methods are available. He needs information that will enable him to weigh the longtime benefits that control will bring in terms of yields and dollar returns against the costs of control. White pine blister rust and dwarf mistletoe in ponderosa pine are two diseases that illustrate this need very well.

This third type of appraisal poses a very difficult and complicated problem because we may need to predict for a whole rotation ahead what our yields in terms of volume, quality, and finally dollars will likely be, with and without control. Usually some evidence can be obtained from existing stands on the influence of various degrees of infection on stand factors such as stocking, growth, mortality, and log quality. But putting these individual pieces of information together into a sound prediction of future yields is no small task. A few of the possible stumbling blocks that should at least be recognized are:

(1) That the control operation itself may strongly influence stocking and future yields, irrespective of the presence or absence of disease.

(2) That evidence gathered in existing stands cannot always be used without modification for predictions because future stands will be very different from the old-growth or transition stands with which we are currently dealing.

(3) That estimated losses from mortality alone will need to be discounted appreciably because periodic salvage will doubtless be a common practice in accessible forest areas.

(4) That yields at final harvest cutting may represent only one-half to two-thirds of total yields because a substantial proportion of total production will be realized through periodic salvage cuttings and commercial thinnings.

In pointing out some of the difficulties in economic appraisals of costs and benefits of disease, I do not mean to imply that the job is insurmountable or should be postponed until better biological and economic information is available. I do want to emphasize, however, that this type of appraisal is needed by forest managers and that it deserves the best combined efforts of pathologists, silviculturists, and forest economists.
GROUP DISCUSSION OF "DAMAGE APPRAISAL"

The most important part of this problem is extrapolation of damage estimates from young to commercially mature stands, since the only realistic criterion of damage by a disease is the effect of the disease on the crop. Multiplicity of factors makes this extrapolation very difficult.

Functions of pathologists and forest managers in the field of damage appraisal need clearer definition. Emphasis was again placed on the necessity of getting research results into use, even though they may be only tentative.

2. Decay Study Methods

RECORDING DATA IN THE FIELD, AND METHODS OF COMPUTATION

By James W. Kimmey

Introduction

Methodology in decay studies has varied considerably throughout the United States and Canada. And it has varied significantly here in the West. There has been some variation between Stations in the same organization, and even within a single Station the methods have varied with different decay studies. I am sure that it is the general consensus of this group that uniformity of methods in most phases of decay studies is not only desirable but essential. Uniformity is necessary if the results of various studies are to be compared or combined to obtain an over-all analysis of the decay conditions in our forests.

The first step in obtaining uniformity in methodology is to discuss the methods now being used. We should discuss methods of sampling, the bases required, our methods of recording field data, methods of computation, compilation procedures, and the presentation of results. Our first panel will lead the discussion on methodology. To start off this discussion I am going to describe the methods our Station has been using to record field data, and our methods of computing the data.

Recording Data in the Field

In various decay studies in which I have participated in Alaska, the Pacific Northwest, and in California, we have found the most versatile and efficient field form to be a modification of the old Forest Service form 558a. The negative for the revised form is on file at the California Forest and Range Experiment Station.
A separate sheet is used for each study tree. We use this form for recording everything except a general description of the study area, which is written up separately on the area at about the time the work is completed there and after we are entirely familiar with all conditions where the data were collected. The advantages of the form are many. All field data for a tree are on a single sheet, including a scale diagram of the entire bole from the ground to the tip. All computations are also made on the same sheet. The reverse side of the sheet has 12 longitudinal and 13 cross-sectional forms for diagraming any unusual cull conditions at any point of examination.

**General Tree Notes**

The form heading for each tree sheet includes the name of the study area, its detailed location, and the subregion. It includes timber type, elevation, slope, aspect, and site; and the species, tree number, age, and d.b.h. Also in the heading we record measurements for form class, break locations, the utilized top diameter, and diameter at the middle of the first log. This last measurement is usually at 8 feet above the theoretical or standard stump height, regardless of the actual stump cut. The purpose of this measurement is to have an exact diameter for determining the cubic volume of the butt log, which often has excessive taper. The center diameter of the other logs may be accurately read from the tree diagram. Cull indicators are listed in the heading for ready segregation of trees in compilation. A small space is also available for general notes. When more space for such notes is required the reverse side of the sheet is used. The workers' and note keepers' initials and the date are also recorded in the heading.

**Tree Measurements**

The bottom third of the form is practically identical to that part of the old 558a form where the tree bole is plotted to scale on a semi-log graph.

The central part of the form contains space for recording length and diameter measurements for the stump, 15 logs, and the top. Also circular or squared cull measurements may be recorded for each log, and space is provided for recording detailed cull data at 17 locations in the bole. The cull indicators may be listed by type and location. All locations are designated by their distance above the ground (on the uphill side) when the tree was standing.

Stump and log lengths as actually cut are not recorded in the spaces, but theoretical or standard lengths are recorded in the office and applicable diameters are then read from the graph and recorded in their spaces. Tree diameter measurements in the field are always made at the stump, at 4.5 feet above the ground, at 8 feet, and at 16 feet above the theoretical stump, and at the utilized top. Other diameter measurements are made
wherever bucks occur, in logging areas, and wherever needed in dissection studies. The location of the 8-inch d.i.b. is determined in the field, and designated on the diagram. All d.i.b. measurements are plotted on the diagram, and those at the middle of the first log and the utilized top are recorded in the heading. Diameter inside the sapwood as well as the d.i.b. is diagramed for the entire length of the bole.

Cull Measurements

Diameter inside rot, including all visible stages of decay, is plotted and diagramed, and the cull portion crosshatched. Cull measurements are made at the stump, at all other bucks, and at breaks where possible. If these are not sufficient to indicate the limits of the rot, borings with an increment borer are made, or if the tree section is not to be utilized the rot may be traced out by chopping into the bole at desired intervals. All cull, in addition to decay of all visible stages and including shake, crook, or other "sound cull," is plotted on the diagram. The locations of breaks are recorded in the heading, and also may be indicated on the tree diagram.

Cull Data

The spaces provided for recording cull data include first a column for location of the examination, which is the distance from the ground. At each location the species of fungi are recorded and the percentage of incipient and percentage of typical rot caused by each species is recorded in the spaces provided. Shake, or other sound cull, except breakage, is also recorded. Shake is usually classified either as circular or cross shake or both circular and cross shake, and the percentage of the total cull caused by it at each point of examination is recorded.

Symbols or initials are used to record the type of cull indicators found. These are recorded both in the heading and in a column in the central portion of the form, where the location of each indicator is also recorded. In addition the locations of the indicators, especially conks, may be designated on the tree diagram.

Tree Diagram

The diagram of the tree bole on the semi-log graph, at the bottom of the sheet, is plotted to the diameter and height scale best suited to the size of each individual study tree. Three diameter scales are given on the form. Trees about 15 inches d.b.h. or less are plotted on the inside scale. Trees 15 to 35 inches d.b.h. are plotted on the outside scale times 10, and trees 35 to 70 inches on the middle scale times 10. Larger trees are plotted on the inside scale times 10. At times the lower portion of the bole may be plotted on one scale and the upper part on another. This is especially true for trees over 70 inches d.b.h. or for trees with excessive butt swell.
Only one height or length scale is given on the form. However, trees 160 feet or less in height are usually plotted at half the scale given on the form. The diameter and height scales used for each tree are designated on the form. The total height is recorded in the space provided in the lower right corner of the form.

**Computation Methods**

All individual tree computations are made directly on the tree sheets in the space provided on the right of the central section of the form.

**Board-foot Computations**

All of our board-foot computations have employed the Scribner Decimal C rule. This is the local standard rule in California and the Pacific North-west as well as Alaska. However, the standard rule for the Forest Survey in the entire United States is the International 1/4-inch log rule. Our cull factors determined by the Scribner Decimal C rule are applied to gross volumes determined by the International 1/4-inch rule in Forest Survey published reports. We have used the Scribner Decimal C rule because our cull factors are widely used by practicing foresters in federal, state, and private industry in the region where the Scribner Decimal C rule is the standard. However, since the primary purpose of the cull factors was for use in the Forest Survey there is logical argument for our use of the International 1/4-inch rule in computing our cull factors.

Stump heights standard for the region are first marked off on the tree diagram. From this point standard log lengths are marked off regardless of actual usage in study areas. Log lengths and d.i.b., at the small end are then recorded in the columns provided. Gross board-foot volumes are recorded to the utilized top and to a fixed top—usually 8 inches d.i.b.

Scaling and cull deductions in board-feet are made in accordance with the U.S. Forest Service Scaling Handbook. Thus the cull volume is somewhat larger than the volume of rot, as the scaling rules cull considerable sound material. For this reason the relative abundance of rot caused by the various fungi is computed on a cubic volume basis rather than a board-foot basis. However, the relative importance of the various fungi in causing cull is based on board-foot computations, as is the relative importance of shake, crook, etc., in causing cull.

Breakage volume in board-feet is that volume of material broken in felling less the volume that would have been culled for other defect in the broken sections of the bole had there been no break. Breakage in cubic feet is computed the same way except that cull caused by rot is the only deduction from the gross breakage volume. In other words, shake, crook, and other sound defects are not considered cull in cubic foot computations. In board-foot computations unbroken bole sections less than 6 feet long between breaks are considered part of the breakage.
Any log less than 6 feet in length (the top log to either the utilized or fixed top) is considered to have no gross board-foot volume.

**Cubic foot Computations**

In some of our studies we have included the volume of the stump in cubic foot computations. The Forest Survey gross cubic foot volumes do not include the stump, therefore our cull factors should not include it. This decision is based on present-day usage. There is a question, however, whether computations including the stump should not also be made. The relative importance of butt or root rots compared to trunk or top rots may be changed considerably if rot in the stump is disregarded. We have therefore based the relative abundance of rot caused by various fungi on cubic volumes, including the stump as well as to top above the utilized or the fixed diameter limit.

Log lengths used in cubic volume computations are always 16 feet except for redwood, other conifers in the 12- to 21-inch d.b.h. class, and for hardwoods. In the latter two cases 8-foot logs are standard and for redwood 20-foot logs are standard. Gross volumes in our earlier studies were determined by planimetering the diagram. In our later studies we have used tables based on the average middle diameter.

In scaling, rot deductions were formerly deductions of the actual volume of decayed material, where we planimetered the cross hatched area on the diagram. In our Alaskan cull study we calculated the cubic cull volume by squaring the average center diameter (in feet) of the cross hatched area and multiplied by its length. This procedure is based on sawtimber or plywood use. In our California cull studies cubic cull volume is based on pulp or chipwood use, and the method is changed to figure the rot as a cylinder rather than squaring it. In this method the cull volume is determined from the same tables as the gross volume.

Cubic volumes are computed to the actual utilized top and to a fixed, 4-inch d.b.h. top. Both gross and cull volume include logs less than 6 feet in length.

**Checking Computations**

By totaling the log volumes of a tree in the gross, cull, and net column the checking of computations is largely automatically achieved. That is, the combined totals of the cull and the net columns must equal the total of the gross column. This same system of checking is used for compilations, when the totals of all three columns are compiled.
Significance of Fungi

The significance of each fungus species is determined on the basis of cubic volumes of cull caused by the fungus. The percentage of rot in the typical stage (decayed material that will not make lumber even of low grade) and the percentage of rot in the incipient or early stage is computed for each causal fungus. The decays are classified as either white rots or brown rots and the total significance of each of these types of rot is computed, and the percentages of incipient and typical stages determined.

Significance of Cull Indicators

After all individual tree computations are completed, compilations and analysis are made by sorting tree sheets into various categories. The significance of each type of cull indicator is thus determined. A further breakdown for each type of indicator is then made to determine the significance of the location of the indicators on the tree. Likewise the significance of size or number of indicators is determined. Combinations of indicators by types, location on the bole, and a number of other individual tree variables such as diameter and age are analyzed in the same manner.

Possibility of Using Punch Cards

Recently we have considered the use of punch cards for recording individual tree data. There is no doubt that analysis could be more thoroughly and efficiently done if punch cards could be used. However, the complex and detailed type of field notes required in decay studies probably prohibits efficient use of mark-sense cards in the field. If a system of punch card recording field notes could be worked out, it would undoubtedly be so complex that the time required to record the data would be excessive. Then the question would be: Would the time saved in the office computations and compilation more than compensate for the extra time required in the field. Time in the field is considerably more valuable than office time, because greater technical skill and therefore higher salaried men are required in field work than in routine computation and compilation work. In addition, field men usually are collecting per diem and have other costs that office help does not.

Perhaps the most efficient use of punch cards would be to transfer the data to the cards in the office after individual tree computations are completed. The time required to transfer the volume totals and other individual tree data would probably be more than compensated for by time saved in compilation and analysis. Further advantage would be the more thorough analysis ordinarily made when punch cards are used.
Conclusions

I have now given you a rather sketchy description of our methods of recording and computing data in decay studies. Undoubtedly our methods vary in numerous ways from those you employ in similar studies. The fact that we often make changes in our own methods illustrates that improvements are always desirable and possible.

Although our basic aim in this discussion is to strive for uniformity of methods, we should at the same time strive for the best and most efficient methods. I hope I have aroused sufficient questions and ideas for a thorough discussion on the subject.

METHODS IN DECAY STUDIES

By Ernest Wright

My discussion will be confined to the methods in decay studies that we have used for beetle-killed timber and for logging-scarred trees.

Beetle-killed Timber (West of Cascades--Douglas-fir and True Firs)

I will not go into detail about our methods of recording rot data in the field. The form which we use is very similar to the left half of the California form. The data are computed or plotted on separate sheets in the office after the field season.

For beetle-killed timber, I first want to emphasize the importance of using trees of known mortality classes. Not only is the exact year of kill important, but also the season of infestation, i.e., whether early summer or early fall. Such studies need to be carried on in direct cooperation with entomologists. Mortality plots should be established at the beginning of an infestation and trees should be tagged by number and year of death thereafter. After felling, it is necessary to have an entomologist make a critical examination of the boles to determine if any important repulsed beetle attacks had been made, as well as their extent and severity, before the trees succumbed. This is necessary because we have found that the extent of decay is directly related to the area of infestation on the bole.

General notes on area description, site, exposure, slope, character of stand, etc., are as necessary in these studies as in any decay studies.

Trees selected for felling and dissection should be well distributed throughout the plots or selected at random along a strip or transect line. After felling, the trees are bucked into commercial log lengths or into shorter sections, depending on the nature of the operation. After bucking, it is necessary either to break the logs apart at the cuts or to make additional disc cuts so that the ends will be exposed for examination.
Measurements consist of diameters of the logs inside bark at both the small and large ends, or one diameter can be taken in the middle of the logs. I prefer the former because it gives complete rot penetration data. The percent of advanced, intermediate, and incipient decay on each log end or cut can be estimated and the depth of rot penetration recorded. The data thus collected can be plotted on tree form charts, or volumes in cubic or board-foot can be determined by computation or from log scale tables.

Height measurements can be taken only to the commercial log diameter limit or to the total height of each tree, depending upon the objectives of the study. Culture blocks, identification of rots, locations of sporophores, etc., are recorded as the dissection progresses. Each cut is numbered consecutively for each tree so that the logs may be followed into the mill and estimates on decay losses may be checked if desired.

**Scarred Trees**

Logging scars are caused mainly by skidding, by tractors, and falling trees. The dissection is usually started at the middle of each scar, and the decay is traced below and above the top of the scar. Much of the same procedure can be used for scarred as for beetle-killed trees, except that the decay here will be found to be associated with the scars, broken tops, or sunscald areas. The advance of decay, therefore, needs to be determined for each scar separately. Where multiple scars are present the rot is recorded in the same manner, but the data from multiple scars cannot be used in all calculations. Tree diameter, and position, width, and extent of scar are necessary measurements. The most important is the scar age, on which the amount of decay is primarily dependent. All scars, with and without decay, must be included in the analysis; otherwise the data cannot be related to the total damage throughout the stand. After enough data are available a regression formula for predicting decay in different aged scars can be developed on the basis of scar area and scar age.

Coincidentally, it is advisable to record the relation of breakage to the presence of decay and to determine specific gravity losses. For the latter, specific gravity can be related to pulp or lumber yields; this, of course, is another study within itself, and requires a lot of extra work and many additional specimens.

**ECOLOGICAL SITE TYPING AS AN AID TO APPRECIATING DECAY IN STANDS**

By G. P. Thomas

It is standard forestry practice to take cognizance of the outstanding differences between stands, and to identify forest units with one or more of such differences. It has become customary, therefore, to partition most forested areas, irrespective of their size, into two or more allegedly discrete units, each unit being somehow different from the others, depending upon the basis of segregation. According to the
particular interest of the person or agency drawing distinctions between this or that stand or region, the basis for making distinctions has varied but, in general, it must be acknowledged that the basis of segregation has been rather narrow, and mainly mathematical. The result has been that we, as foresters and pathologists, have learned to depend upon such units as site indices, site classes, forest types, cover types, etc., to categorize our observations, make our evaluations, and even to plan our experiments.

It is possible, don't you think, that in our zeal to categorize our thoughts, evaluations, and results of experiments, that we have made too free and consistent use of systems for partitioning forest areas without due regard to the basis upon which the distinctions between forest units were drawn. The systems most commonly used, and which have been perfected in their application to the greatest degree, have been those that require precision of measurement and statistical support, certainly more so than systems requiring powers of observation and exercise of judgment. We have learned to depend upon mathematical treatment of one or a very few values, rather than to consider a number of values together. For example, we rely upon our ability to decide that stand A, having a volume by species of western redcedar 65 percent and western hemlock 35 percent, is a quite different condition from stand B, having a volume by species of western redcedar 35 percent and western hemlock 65 percent. Stand A is referred to as cedar-hemlock type, whereas stand B is hemlock-cedar, a real difference being implied. We now feel at liberty to categorize our observations, be they pertinent to disease growth, mortality, etc., according to one or other of these two types. Such an approach has been carried even further, when we decide that stand B1, being hemlock-cedar type in which dominant hemlocks achieved a height of 80 feet in 100 years, is site 80 or site class III, whereas stand B2, also being hemlock-cedar type but in which dominant hemlocks achieved a height of 100 feet in 100 years, is site 100 or site class II. Once again we feel at liberty to categorize our observations, whatever their nature may be, according to one or other of these two site indices or classes.

Now I admit that I have placed an extreme interpretation upon our methods of categorizing forest units, and of our general use of these categories, but I must draw your attention to the fact that we almost invariably categorize our observations on just such bases as I have mentioned. Such systems as I have outlined most certainly have their place in forestry, but I submit that their application should be limited to the specific use for which they were designed, and also that they tell us very little about a particular stand, or area, in relation to another stand or area. Such systems, by utilizing one or a very few tree or stand characteristics as their basis, create, for the most part, artificial units that may have no bearing upon pathological considerations of forests. Have we not become rather remote from a more natural basis for segregating forests into discrete units, and in so doing, may we not have reduced our approach to biological considerations in forests to an inflexible mathematical treatment?
There are systems for classifying forest units available to us which, I believe, offer many advantages for subsequent interpretation of biological phenomena. The systems to which I refer are those which recognize the plant association as the fundamental unit of classification. The term "plant association" to which I refer is that regarded by the World Botanical Congress as "a plant community of definite floristic structure, presenting a uniform physiognomy, and growing in a uniform habitat condition". There are several of such systems in use in forestry today, all somewhat different and all useful under particular circumstances. Despite their differences, they nearly all have one feature in common, that being the ease by which they may be recognized by the occurrence of plant associations. These systems differ mainly in the basis for their derivation, some relying totally upon the occurrence of one or a few dominant plants and others requiring consideration of plants in a more complete sense plus recognition of factors of the atmosphere, topography, soil, and substratum, i.e. the characteristics of a specific ecotope. The utility of any one of these systems will depend very largely upon the number of habitat factors that operate in a region to produce different habitats and the number of such factors that any particular system employs in the derivation of these habitats. Used with discretion, there are a number of such systems, which may be called natural systems or ecological site type systems, available for our use in forest disease work. The most truly ecological of these systems is one which combines the characteristics of vegetation, atmosphere, topography, soil, and substratum and is recommended for use in mountainous areas, or in areas where mountains greatly affect the local climate. It is important to realize that both the derivation and description of site types require evaluation of the characteristics of their vegetation and specific ecotope. Site types so derived are expressed by their floristic structure, and in themselves express the conditions of the habitat. Such a system, employed in any area, will yield a series of site types that are, in effect, natural units of vegetation and which can be studied in any one or more of their characteristics, just as is done in the case of cover types, site indices, etc.

For a number of reasons I strongly recommend the use of some classification scheme in forest pathological work that will create natural units of forest cover, to which we may refer our observations with some assurance that they are being properly categorized. Is it not true that we tend to accept the segregation of forest cover into units, irrespective of the basis of segregation, and then to describe these units in our own particular ways, assuming all the while that the units we are dealing with represent the range of conditions necessary for an effective evaluation of a forest disease problem. Don't you think we either spend a lot of time describing conditions that have no bearing on our problem, or alternatively, that we rely too often upon the determination of site index, cover type, etc., without benefit of further description? How often are our reports prefaced by "study area descriptions" or "stand descriptions" to which little or no reference is made in our interpretations of the results of investigations. I believe that these tendencies arise out of misapplication of the units of forest classification in general use.
Whose responsibility is it to derive site types, and how long must we wait for them to be derived and described such that we can use them? There has already been considerable work done along these lines in the West. Already there exist adequate site type descriptions for a number of forest regions, and the work is continuing. In answer to those who feel it presumptuous or inadvisable for pathologists to attempt site type classifications, and that such a task lies within the province of forest ecologists, I would say that we have neither the time to waste, nor the moral right to wait for someone else to complete this work. Every forest pathologist and forester is something of an ecologist, even though he may not consider himself an expert. Provided he follow a prescription for deriving site types such that his techniques are consistent, and provided his prescription will yield him site types useful to his investigation of forest disease, I believe every forest pathologist should consider it a routine part of an investigation to proceed with site type classifications as the need arises. If a classification has already been made, and if the classification meets the requirements of his investigation, he is indeed fortunate, but the lack of a classification should not be allowed to hinder his investigation when he has the ability to carry out the work himself.

The mechanics of deriving and describing ecological site types for an area, drainage, or region are fairly standard, irrespective of the system you wish to apply. A system which I have used in British Columbia requires an analysis of both the vegetation and the main characteristics of the ecotope. It is a system that yields results directly comparable to the work of other investigators irrespective of the person making the evaluations. I have used this system in the past few years to determine hemlock and balsam site types necessary to an evaluation of the Indian paint fungus. Some of the areas I examined in the course of this work had already been site typed by other investigators who had used the same system of classification. In other areas I was forced to make my own classification. I have found no difficulty in combining my own results with those of other investigators and they, in turn, have not been too shocked at my efforts. I found the following data useful, and for the most part essential, to deriving and describing site types:

I. Vegetation— all vegetation within the forest condition is listed according to its vegetative layer as follows:

- A1—being dominant and co-dominant trees
- A2—being intermediate trees
- B1—being overtopped trees and shrubs more than 6 ft.
- B2—being overtopped trees and shrubs less than 6 ft.
- C—being herbs
- D—being mosses and lichens as they occur on the ground, on rotting wood, and on the bark of trees. Tree seedlings are also recorded in this layer.
the vegetation as listed in each layer is estimated as regards its abundance, sociability, and vigor as follows:

**abundance** -
+ meaning solitary occurrence  
1 meaning scattered occurrence  
2 meaning occupies up to 1/5 of the area  
3 meaning occupies 1/5-1/2 of the area  
4 meaning occupies 1/2-3/4 of the area  
5 meaning occupies 3/4-entire area

**sociability** -
+ meaning solitary or scattered occurrence  
1 meaning in colonies up to 1 sq. ft.  
2 meaning in colonies up to 1 sq. yd.  
3 meaning in colonies up to 5 sq. yd.  
4 meaning in colonies up to 100 sq. yd.  
5 meaning in colonies up to 500 sq. yd.

**vigor** -
0 meaning dead or dying  
1 meaning low vigor  
2 meaning intermediate vigor  
3 meaning maximum vigor for the region

II. Ecotope - the characteristics of the ecotope are measured or estimated as follows:

1. elevation, measured in feet above m.s.l.  
2. exposure, measured by compass direction  
3. slope, measured in degrees  
4. wind influence, estimated according to the degree of exposure to the maximum wind influence of the area  
5. snow cover, recorded as the duration, in months, of continuous snow cover  
6. soil and substratum, are measured and described, using two or more soil pits per plot, according to the different horizons and layers as follows:

**Ao** - being the humus horizon, including the litter; measured as to total depth, depth of litter, and classified as to raw, duff mull, or earth mull humus

**A1** - being the melanized horizon; recorded as being present or absent and measured as to depth

**A2** - being the podzol horizon; recorded as to depth, color and structure
B - being the enriched horizon; recorded as to depth, color, texture, and structure
C - being the parent material
D - being the glei horizon; recorded as to presence or absence and location in the profile
- additional features of the soil are noted as follows:
  a) depth of the fine soil (in inches), being somewhat indicative of the effective rooting depth of trees
  b) soil moisture, a relative estimate applied to the different horizons of the profile
  c) drainage, with respect to degree of drainage

The above description of each forest condition is prefaced by the name of the site type, geographic location of the area examined, the date, and the plot number. Notations pertinent to the history of the area are appended to each description.

While it is preferable to derive site types for a region prior to using them in disease investigations, it is entirely feasible for disease evaluation to proceed together with the derivation and description of site types in some cases. If these operations are combined, I would suggest that the initial emphasis be placed upon site typing rather than with disease evaluation, but once the framework of sites has been derived for a region I have found that disease evaluation can proceed together with site descriptions quite well. Eventually, by this process, disease evaluation becomes the dominant operation and site typing becomes mainly a matter of site type recognition.

When forest cover is examined along such lines as I have indicated it is possible to recognize very quickly the similarities and differences that occur between stands, or any form of forest unit. If a specific disease is referred to one or several site types so described, an investigator is not only in a good position to recognize degrees of occurrence and damage but is also in a good position to select habitat components for more detailed examination as they may affect the disease. At the same time he will have preserved the identities of his original site type descriptions. It is possible that in making site type descriptions of areas supporting a diseased condition, insufficient emphasis will have been placed upon habitat factors that later prove to be the most operative as regards the particular disease. This fact in no way detracts from the value of ecological site typing in forest disease work, but rather enhances it, inasmuch as at least a basic minimum description of the important factors has been provided for each area examined.

Depending upon the disease under examination, and the plant parts affected, an investigator can pay more, or less, attention to the component characteristics of the site types that support occurrence of the disease, provided
that a full description of the site types in question is made for the purpose of including the less important, but nevertheless contributing, factors of the environment. In the case of root diseases, even though a detailed examination of the soil factors of the habitat may be called for, the results of such examinations should be considered only in relation to the part that soil factors play in regulating the complete habitat condition, and not to the exclusion of the roles of other habitat factors. In the case of stem diseases, the results of detailed examinations of the aerial components of the habitat should be considered only as they augment the remaining operative factors, and not to the exclusion of them.

In our studies of decay in stands we have been inclined to think mainly in terms of volumes associated with tree size and age. We have been less inclined to consider the circumstances necessary for decay to develop, and that these circumstances may be expressed in the appearance of trees and stands other than in their size and age. It is true that we sometimes make use of decay indicators to refine our estimates of the frequency of decay in trees, but we seldom try to relate the presence and significance of decay indicators to features of the habitat. Perhaps our failures to report on the circumstances of decay development is allied to our failure to admit that decay in trees can be influenced by a number of factors of their environment and not merely their size and age. In this respect, site type classifications automatically provide suitable units of forest cover for study. For example, I have noted that the fruiting habit of *Echinodentium* on alpine fir is fairly consistently correlated with the location and amount of decay in this species. I have noted also that the fruiting habit of *Echinodentium* can be correlated with the different conditions of atmospheric moisture and temperature throughout the bole length of trees. These atmospheric temperature and moisture conditions are expressed by certain features of alpine fir habitats that are included in site type descriptions of alpine fir forests. Hence it is possible to identify specific conditions of *Echinodentium* development by recognizing the occurrence of alpine fir site types. I cite this example only to show that the circumstances determining the occurrence and amount of decay can be effectively appreciated by using site type techniques as the basis for setting up an investigation.

Changes from one site type to another are often quite frequent over short distances but, so readily may site types be recognized, these changes can be easily detected, not through laborious vegetational analyses but rather merely at a glance. It is sometimes argued that site type changes over a short distance are so frequent that it becomes meaningless to take them into account. It is further argued that site type changes are so frequent that the use of site types hinders rather than facilitates investigations, inasmuch as it is difficult and often impossible to locate sample plots within uniform conditions. Exponents of such arguments generally feel that an average of the conditions represented by an intimate mixture of site types should be struck and sampled accordingly. I cannot agree with these arguments. In the first place, I doubt the ability of most investigators to strike a true average for such a condition, but most of
all I doubt the value of an average. The occurrence of a site type repre-

cents something quite definite and the occurrence of two site types demon-

strates a difference. Surely an investigation of forest conditions, be

ey concerned with disease or some other factor, must pay attention to
differences between habitats. Furthermore, the time to think and speak of
average conditions is not during the course of an investigation, but rather
after completion of an investigation that is based on differences. An ex-
ample of reliance upon an average value representative of mixed conditions
is contained in the following comparison of two sample areas of hemlock for-
est, the average value in this case being site index 80*:

| No. of trees | Av. diam. (in.) | Av. age (yr.) | Av. gross vol. (cu. ft.) | % gross vol. of Echino-dontium cayed by | % gross vol. of Echino-dontium cayed by | % gross vol. of all fungi | % trees inf.
|-------------|----------------|--------------|--------------------------|---------------------------------------|---------------------------------------|--------------------------|----------------
| Stand 11 in. dbh & over. | A | 40 | 16.8 | 219 | 145 | 2081 | 894 | 43 | 50 | 72 |
| | B | 57 | 19.1 | 229 | 137 | 4726 | 1375 | 29 | 54 | 44 |

The same areas when classified on a site type basis showed them to be quite
different, each representing a definite site type. The greatest similarity
between these two samples lies in the cull percent ascribed to all fungi
combined. Here the similarity ends, other than in their site index. Fur-
ther comparisons of stands of the site types represented by stands A and B
showed that each of the two stands in question very closely resembled others
of its site type. Thus, site index, when applied to these two stands, did
not appreciate sufficient of the differences that actually occurred between
them. The overemphasis placed upon site index or site class, as a basis for
distinguishing between stands in the region from which these two samples
were drawn, is further reflected by the quality of the supplementary descrip-
tions provided for the sample areas. Without re-visiting the areas concerned
it would be impossible to account for the differences between them.

In conclusion, may I suggest that more reliance be placed upon systems of
forest classification that yield essentially natural units of forest cover,
rather than to continue our dependence upon systems that yield essentially
artificial units.

* Site indices were based on age-height curves extended beyond 160 years
and on the average height of the dominant tree of average diameter as
read from d.b.h.-height relationships for each plot. It is admitted
that relative, rather than actual, site index values were obtained in
this way.
GROUP DISCUSSION OF "DECAY STUDY METHODS":

No satisfactory definition of cull exists, since so much depends on the type of utilization and this cannot always be known for a given log.

Experience of various members of the Conference supported Thomas' contention that real differences exist between almost any two samples, and that efforts at grouping and interpretation must therefore be made with care.

3. Uniformity in Procedures and Presentation of Results in Decay Studies

UNIFORMITY IN MEASUREMENT DATA AS APPLIED TO STUDIES IN DECAY

By R. E. Foster

During the course of our second annual meeting, reference was made to an apparent lack of standardization in methods of analysis of decay. Casual reference was made at that time to the lack of uniformity in measurement data. Since then, information has come to hand to indicate that this particular lack of uniformity is worthy of special reference.

To determine the extent to which lack of uniformity in measurement data might prevail, a diagram of what might be considered an average west coast log with pattern of decay was prepared. This diagram showed a log 30 feet long with basal and top diameters inside bark of 22 and 16 inches respectively. The log showed decay at the basal end measuring 19 inches in diameter and extending 21 feet. The diagram was submitted to a number of colleagues with the request that board- and cubic foot volumes be computed according to prevailing standards. The answers received will be referred to in some detail as they are pertinent to the theme of this paper.

Variations in volumetric computations in Canada

Forms were submitted to Forest Pathology laboratories in New Brunswick, Ontario, Saskatchewan, Alberta and British Columbia. These laboratories reported the volume of decay, expressed as a percentage of the gross board-foot volume of the log, to be 68, 73, 75, 76 and 85%. The weighted average cull factor was 74% and the range 17. No two laboratories provided exactly the same answer. With arbitrary culling standards similar to those in effect at two of the laboratories, moreover, the maximum amount of defect would be increased to 100% and the range in values between laboratories thus increased to 32%.

Certain of this variation may be explained on the following grounds:

1. At least three different log scales were employed, the New Brunswick, Scribner and British Columbia Scales. These different scales provided gross log volumes which ranged from 300 to 430 board-feet, the maximum value being 43% greater than the minimum.
2. Varying standards of maximum permissible log lengths were employed. Thus between laboratories the log was scaled in one or more combinations of 8, 14, 16 or 30 feet.

3. In at least one laboratory the diameter of decay was increased by one inch, presumably to allow for trim. This practice increased the regional decay volume computation by 8%.

4. Different formulae were used in computing decay. In one case table values were used for a log 19 inches by 14 feet, in another case the formula $D^2 \times L$ over 15 was employed with $D$ equal to the maximum diameter of decay, in another case the formula large $D \times$ small $d \times L$ over 15 was used with large $D$ equal to the maximum and small $d$ equal to the minimum diameters of decay. Two laboratories culled the entire volume of the log, but for different reasons, one because it would not provide 50% of the gross volume in sound wood and the other because it would not cut out 33% of its volume in sound wood.

This appraisal should lead to the conclusion that there is little scientific value to be derived in comparing board-foot computations for decay since it is impossible to separate real differences from those arising through different measurement techniques. This consideration has perhaps long been appreciated. As one laboratory noted, "Our laboratory uses two methods of computations, one based on the board foot scale and modified as required to meet local regulations and interpretations, and one based on cubic feet to provide values on a uniform basis that can be used to compare decay losses in two or more different regions." As this practice appears to be one accepted by most laboratories we can perhaps anticipate greater uniformity in regard to cubic foot computations.

In regard to cubic foot computations the log volumes derived ranged only from 58.9 to 60.8 or 1.9 cubic feet. Most of this variation could be explained as experimental error arising through use of the planimeter and possibly because several adaptations of the original Reinecke tree measurement form have been prepared. All laboratories used Smalian's formula $\frac{1}{2} D^2 \times L$ as the standard or alternative scale to the tree measurement form. In regard to the percentage of decay the different values reported were 34, 35, 39, 50 and 76. The weighted average cull factor derived was 36%. The range was 42%. There were two significant variants, 50% and 76%. The first of these arose through use of an arbitrary culling standard which required that the log scale be reduced by 50% owing to excessive decay in the butt. The second variant arose through use of an arbitrary culling standard which required that all portions of the log containing decay be culled. This latter standard is apparently used only in the case of balsam fir and at one laboratory and is recognized as unrealistic. We could consider, therefore, that the values ranged from 34 to 50, or 16%, in species other than balsam fir.

$$\frac{1}{2} V = \frac{D^2 + b \times L}{2}$$
Since the cubic foot values provided a range only 1% less than that obtained in board-feet it must be concluded that no apparent advantage has been gained through use of the cubic foot computation in this instance. If we could convince one laboratory to drop their arbitrary culling standard, however, the cubic foot range in values would be reduced to 5.2% and if we could convince other laboratories that the formula for a cone differs from that of a non-truncated paraboloid we could reduce our error to approximately 1.5% which is within the limit of our experimental error. Until this is done, however, it is evident that we could be led down the garden path in our interpretations of regional differences in decay.

No attempt was made other than in British Columbia to determine the extent of interregional variation. One laboratory, however, volunteered the information that their value would fall somewhere "within the wide range of values obtained by culling practices in our region".

Within British Columbia forms were submitted to Provincial Forest Service and Industrial scalers.

Completed forms were received from five Forest Service District offices. Values were computed on the basis of "actual" and "practical" standards. In the case of actual measurements in cubic feet the percentages of decay reported were 23, 26, 33, 42, and 51. The average cull factor derived was 37% and the range 28%. In the cubic scale the practical measurements averaged 59% and ranged 17%. In the case of actual measurements in board-feet the percentages of decay reported were 33, 37, 38, 50 and 67. The average cull factor derived was 45% and the range 34%. In this scale the practical measurements averaged 49% and ranged 3%.

Seven replies were received from Industry. Percentages of decay reported in cubic feet were 25, 33, 34, 35, 40 and 49. The weighted average cull factor derived was 39% and the range 24%. In board-feet the average cull factor derived was 37% and the range 15%.

Both Forest Service and Industry raised considerable objection to the measurements provided for computation:

1. Some contributors reported that we had submitted a most difficult problem while others indicated that the computations were elementary, or "verging on the academic". One of the latter group stated that all that was necessary was to follow the printed scaling rules. Unfortunately he failed to follow his own instructions and submitted an answer that was in error by 9% according to his own standards.

$$V = \frac{B \times L}{3}$$

$$V = \frac{B \times L}{2}$$
2. One contributor pointed out that our log tapered 1 inch in 5 feet while in his region logs always tapered 1 inch in 8 feet. He did not accept our basal diameter but reduced this from 22 to 20 inches and thus calculated a gross volume that was in error by 11%.

3. Two contributors pointed out that their deductions would vary according to log grade and species. Thus in the case of hemlock and fir their cull factor would be 20% greater than in cedar.

4. Several contributors objected to the fact that the lineal extent of decay was shown as exactly 21 feet. One said that this was impossible as decay always extended 1/3, 2/3 or 3/3 the length of the log. Another contributor reported, however, that these fractions were always 1/4, 1/2, 3/4 or 4/4.

The methods used by Forest Service and Industry in computing the cubic foot volume of decay were many and varied. In general, however, the Forest Service employed Smalian's formula, while Industry reduced the length or diameter of the log. Some reduced the basal diameter by 9 inches, others by 11 inches; some reduced the length by 10 feet, others by 12 feet. Some accepted the diameter of decay provided while others increased this diameter by one inch and others by two inches.

Variations in volumetric computations in Western North America.

Reference will be made only to variations between Forest Pathology laboratories.

In British Columbia all board-foot computations were made through reference to the British Columbia Log Scale. The gross volume was recorded as 300 f.b.m. The decay volume ranged from 204 to 228 f.b.m. and the cull factor from 68 to 100%.

In the United States all board-feet computations were made with the Scribner Decimal C Rule. In coast regions the gross volume was computed as 370 f.b.m. but in southern and central regions the volume was computed as 370 or 382 f.b.m. The decay volume ranged from 140 to 250 f.b.m. and the cull factor from 47 to 66%.

Certain of this variation may be explained as follows:

1. The use of different log scales.

2. The acceptance of different maximum log lengths. These were variously reported as 16, 32 and 40 feet.

3. Some laboratories added 1 inch to the diameter of decay while others accepted the diameter provided.
Different arbitrary culling standards were employed. Some laboratories culled half of the first 1/4 feet, others half of the first 16 feet, some all of the first 1/4 feet, others all of the first 16 feet. In one case the entire 30 feet was culled.

Certain of this variation might be justified, at least in part, through consideration that laboratories were attempting to base their practical computations on regional standards which had been developed or otherwise adopted by the forest industry.

In regard to cubic foot computations all laboratories used Smalian's formula, Huber's formula, or Reinecke's tree measurement form to compute gross volume. Gross volumes ranged from 59.9 to 61.0 cubic feet. This variation arose in part through experimental error in use of the planimeter and in part in error in judgment in estimation of the mid-diameter of the log as required in Huber's formula. The weight of opinion appeared to favor 60.55 or 60.6 cubic feet as the correct gross volume of the log.

Four different methods of decay computation were employed.

In western Canada the log was scaled in all cases as a single 30-foot section and decay volumes were computed as in the case of gross volume. The formula for a non-truncated paraboloid provided a decay volume of 20.7 cubic feet while the Reinecke tree measurement form provided values which ranged from 20.6 to 21.1 cubic feet. The experimental error was thus less than 1%. The weighted average cull factor was 34.4% and the maximum variation 0.8%.

In western United States some laboratories scaled the log as a single 30-foot section. These laboratories computed the decay volume as 13.8 cubic feet by means of the conic formula. Their cull factor amounted to 22.7%. Other laboratories scaled the log in two sections of 16 and 1/4 feet (or 1/4 and 16 feet). Although this procedure would presumably necessitate two formulae to compute decay, as decay would appear at both ends in the first section and only at the basal end in the second, only one formula was applied. This formula was presumably intended to approximate a truncated paraboloid similar to that of Smalian's formula, and with the dimensions provided in the sample log it was reasonably successful in this regard. Thus the decay volume computed was 11.8 cubic feet and the total cull factor 24.6%. The average weighted cull factor for all laboratories was 23.6% with a maximum range of 1.7%.

Canadian pathologists thus applied a cull factor of approximately 34% and U. S. pathologists approximately 26% to the same log. It would be

\[ \frac{1}{4} v = B \frac{1}{2} x L \]

\[ \frac{5}{2} v = (D + d)^2 x L \]

\[ \frac{(D + d)^2}{4} x L \]
helpful if this difference of 8% was consistent in all measurements but unfortunately this is not the case. In other logs of similar size but with lesser amounts of decay it could be demonstrated that the differences might amount to 2% or less, while in smaller logs the difference might exceed 30%. Since we deal with logs of varying size and amount of decay it would be impossible to separate real from arbitrary differences in decay between the two regions.

Discussion

Considerable variation has been outlined in regard to the interpretation of decay in one log. Certain of this variation might be explained on the basis that we are attempting to relate our deductions to different standards of utilization practices in different regions. It is appreciated that considerable variation might be expected from a single sample, but it is emphasized that the variation has arisen mainly because of the application of different rules and standards.6 Even though average values derived from larger samples might be expected to more closely approximate one another the range and variation will still be present. These are inherent problems in the practical interpretation of decay.

Decay studies, however, should have interpretative value for scientific as well as practical purposes and it is with the scientific interpretation that we should have greater cause for concern. Each laboratory has apparently established a standard for scientific interpretation. If this standard differs from the practical interpretation, as it does in most cases, then it should be possible to change the one without regard to the other. In other words, we should appreciate that our existing scientific interpretations are of little value to Industry. Thus, they may be changed without fear that they will be of any lesser value to them. We should also appreciate, however, that our existing scientific interpretations may be of little value to other scientists and that standardization and uniformity are imperative.

It is one of the first objectives in sampling to provide data amenable to evaluation. A further objective is to derive broad interpretations. This latter concept embodies an attempt to elevate sampling above the ad hoc evaluation and is the thesis of those who hold for some degree of uniformity in measures.

Accordingly, in the case of volume and decay it is suggested that one set of measurements be used to satisfy our regional and practical requirements and that a second set be used to provide our regional, interregional and scientific interpretations.

6/ Excluded from the analysis are 2 examples of mathematical error. One error arose through use of the "10 X cubic foot tables" with subsequent failure to divide by 10. The second error presumably arose through a similar miscalculation, but in this case the board-foot volume of the log was shown as only 1/10 of what the contributor obviously intended.
To accomplish some degree of uniformity it is recommended that a committee be established to draw up a preliminary set of standards. As a guide it is suggested that this committee might consider the following points:

1. The adoption of a uniform cubic foot log scale.

2. The definition of accuracy standards, as for example, diameters to be measured to the closest inch and lengths to the closest foot.

3. The adoption of a uniform cubic foot decay volume formula.

4. The rejection of all arbitrary culling standards for logs and trees. Decay measurements to be actual and not arbitrarily increased for any reason.

5. The segregation of breakage losses from decay volume.

6. The measurement of total tree volume for all trees above a standard minimum d.b.h.

7. The definition of minimum and maximum log lengths.

8. The analysis of both living and dead trees with separate compilations summarized for each group.

9. The definition of site by means of (a) reference to average maximum height and age rather than to a numerical value and (b) ecological analysis.

This list is not necessarily complete, but any degree of uniformity that can be reached in regard to the factors listed will contribute to a more reliable interpretation of data than would now seem possible.

**Summary of Values**

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<tr>
<th></th>
<th>Cubic feet</th>
<th>Board feet*</th>
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<td>Average</td>
<td>Range</td>
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</table>

*Bracketed values include 100% cull values.
The importance of complementary cultural studies in decay investigations is indicated by the results that have been obtained from almost every major decay project undertaken in recent years. For example, white butt rot in balsam fir in Eastern North America for many years had been attributed predominantly to Poria subacida (Peck) Sacc. and occasionally Armillaria mellea (Vahl ex Fr.) Quelet. In 1953, however, cultural studies (1) revealed that, in order of importance, the following fungi caused white butt rot in this species: Corticium galactinum (Fr.) Burt, Odontia bicolor (Alb. & Schw. ex Fr.) Bres., Poria subacida, Armillaria mellea, and Omphalia campanella Fr. In pole size stands of lodgepole pine in Alberta, Stereum pini (Schlech. ex Fr.) Fr. was associated with 86% of the infections of red stain in the areas studied (12). Previously, Fomes pini (Thore) Lloyd was thought to be the major organism associated with and causing red stain. These are just two of many examples to be found in the recent literature dealing with decay investigations, examples which underwrite the significance of intensive cultural procedures.

Personally, I believe that the maximum uniformity possible in conducting cultural procedures in decay studies is a desirable principle. I do not believe, however, that uniformity or standardization should go beyond the most routine activities required for interregional comparisons because there is no place in scientific endeavor for infringement on individual expression and initiative. I plan to elaborate briefly on this subject in two parts, as follows:

I. Isolation procedures.

II. Presentation of results.

Since there is no pretense at absolute coverage of this topic within the framework of this conference, I hope some further contribution will be forthcoming in the ensuing discussion from individuals who have had considerable experience in decay investigations.

I. Isolation Procedures

In a decay-type project, the routine techniques for isolating fungi from decays are pretty well established. That is, instruments such as a scalpel, chisel, or chisel forceps as reported by Hubert (5) are used aseptically to transfer a chip of the decayed wood to a test tube containing a slant of artificial medium. One variation from these general procedures applies to basal rots where the Swedish increment hammer is valuable in the rapid isolation of fungi from roots (e.g., Armillaria mellea) (6).
An interesting technique which does not strictly belong in this presentation but which is worth mentioning because it does involve the isolation of decay fungi from living trees, is the utilization of the increment borer to determine the incidence of basal decay in standing trees (13). Under aseptic conditions, the increment cores are transferred to Petri plates or tubes of agar and subsequently re-isolated again in tubes. Etheridge (4) has had success with this technique in Alberta in a study of site factors influencing the distribution of root and butt rots in subalpine spruce.

I believe that materials and methods in culturing decay fungi should conform closely to those employed by authorities in identification work such as R. W. Davidson in the United States and Mildred K. Nobles in Canada. The procedures summarized by Nobles (9) incorporating methods designed by Davidson and his co-workers (2, 3), constitute a satisfactory basis that may be followed by workers investigating decay. For example, cultures should be grown on standard media such as malt agar of known ingredients, and color standards (8) could be used to describe decays from which isolates are made. In recording colors of decays, moisture in the wood samples desirably should be standardized.

It is important that the decay medium conform to that on which stock cultures are grown, since variations in gross characteristics may occur on different media and thus needlessly confuse identification that would otherwise be made on cursory inspection of the test tube.

It also may not be a bad idea in decay-type investigations to follow procedures of isolation comparable to those outlined yesterday in the section on now and modified techniques.

II. Presentation of Results

In discussing cultural isolates of fungi for decay, much of the literature infers a fungus to be a causal agent on the basis of isolation from decay. Obviously, mere association with decay is not sufficient evidence that a fungus is a decay pathogen. In a study of decay in sugar maple in Ontario (11), for example, several fungi were listed to be associated with decay. Next to Polyporus glomeratus Peck, Corticium vellereum Ellis & Cragin was the fungus most frequently isolated. This fungus was not generally isolated from decay of similar characteristics, however, and C. vellereum apparently is a secondary fungus (10). Even numerous and consistent isolation, therefore, is insufficient evidence to determine an organism to be a primary cause of decay.

This brings up an important question. What should constitute critical evidence to define a causal agent for decay? Is it necessary to carry through the rules for pathogenicity exactly as stated by Koch in 1882 (7)? Koch's postulates, originally established to stimulate better experimental procedures on animals, may be summarized as follows:
1. The micro-organism must be associated in every case with the disease, and conversely the disease must not appear without the micro-organism being or having been present.

2. The micro-organism must be isolated in pure culture and its specific characters studied.

3. When the host is inoculated under favorable conditions the symptoms of the disease must develop.

4. The micro-organism must be re-isolated and identified as that first isolated.

With stain and decay fungi it is considered wise by many investigators to adhere to Koch's rules for pathogenicity. This is time-consuming, however, as evidenced by the scarcity of literature to demonstrate decaying abilities of fungi in living trees. In order to have some better indication than an associated fungus may be a causal agent, Koch's postulates might be modified as follows:

1. The fungus must be associated consistently with decay and the decay must be consistent in macroscopic and microscopic characteristics.

2. The fungus must be isolated in pure culture and its specific characters determined.

3. Wood blocks cut from freshly felled trees must be inoculated with the fungus and the characteristic stain or decay must develop.

4. The fungus must be re-isolated consistently from the wood blocks and identified as that first isolated.

Essentially, Koch's postulates are altered by the substitution of wood blocks "in vitro" rather than the time-consuming method of inoculating the living host. It is stressed again that wood-block inoculations do not provide absolute proof of causal properties according to conventional concepts but they do contribute firmer indication that a fungus may or may not be a decay pathogen. Further, possible chemical changes in test blocks caused by autoclaving should be avoided by adopting alternative sterilization techniques.

In presenting the results of culturing of decay fungi, the discussion might take at least three avenues:

1. The fungi determined to be causal agents for decay.

2. The fungi associated with decay and of unknown decaying properties.
3. The tabulation of all fungi isolated from decay, particularly the non-Basidiomycetes and discussing, as well as the data will permit, their significance in the incidence picture of all fungi isolated.

In summary, Gentlemen, the following points are emphasized:

1. Isolations of decayed wood should be made on suitable artificial media of known ingredients and known proportions, to conform with media in stock culture collections and media used by specialists.

2. Wood block inoculations should complement the results of cultural isolations in order to provide firmer indications of the possible decaying properties of fungi isolated from decay.

3. Tabular data should include a record of all isolations, identified as to species, if possible, and at least in broad groups, and to discuss the significance of the incidence of non-Basidiomycetes associated with known decay pathogens. This is a point that most decay papers have treated inadequately. The significance of microorganism populations and metabolic successions may receive some elucidation through more critical recording and evaluation of cultural data.

4. I believe uniformity in routine procedures is desirable in cultural studies in decay investigations. I do not believe, however, that standardization should be extended beyond the most routine procedures required for interregional comparisons because there is no place in science for infringement on individual expression and initiative.

References


GROUP DISCUSSION OF
"UNIFORMITY IN PROCEDURES AND PRESENTATION OF RESULTS IN DECAY STUDIES"

Sentiment was divided on the necessity for rigorous adherence to Koch's postulates in studies of decay in living trees.

The consensus of the group favored establishment of a committee to promote standardization of scaling practices to permit interregional comparisons of results of decay studies.
As we all know from hard experience, foresters must deal with ranges of environmental conditions much wider than those ordinarily encountered in agricultural research. For reasons with which you are also familiar, we can study, with reasonable intensity, only a minute portion of the total acreage with which we are concerned. These difficulties are not peculiar to forest disease research; however, they are perhaps even more acute here than in other fields of forest research, since our variable, disease, is not only a highly erratic one but is also superimposed on such other variables as stand composition, density, and site.

Although none of us ignores these considerations, we relegate them too often to the background of our thinking when we plan our work. I can't tell you how to overcome these difficulties. My purpose here is simply to urge that each of you gives them intensive thought, that you watch for ways in which they can be partly circumvented on your projects, and that you pass on to future gatherings of this group any promising results. To start the ball rolling, I'll discuss a few miscellaneous points that are more or less pertinent to this general subject. No doubt you have already considered many of these points, but they may serve to illustrate some of the methods we can use to make our sampling more productive.

First, let's think about how we can get the most out of our permanent plots. When we establish them, we have to spend a lot of time on "overhead" activities, such as marking boundaries, tagging trees, and measuring diameters. When we examine them, we have to spend time in travel to and from the plots, and in walking from tree to tree. These "overhead" costs are increased only slightly, if at all, by use of the plots for multiple purposes, and in many instances the increase in time spent on the actual examination, and on recording data, need not be excessive. If we keep reasonably detailed notes on all significant or potentially significant diseases, we can gradually accumulate information on a number of low-priority questions that will not otherwise be answered within the foreseeable future. At present, we cannot afford to establish plots specifically for the study of such things as cyclic fluctuations of Fomes pini in Douglas-fir stands, mortality rates of heart-rotted trees, and periodicity of fruiting of Polyporus schweinitzii. We need to know more about these things, and our best chance of learning is in connection with higher-priority projects.

In occasional instances, comprehensive disease records may even make a plot more useful for a secondary purpose than for its original
primary purpose. For example, a complete and detailed history of a needle blight outbreak would be of great value, but we can get such information only by accident. The chance of having a serious outbreak develop on a given acre is far too small to justify plot establishment for the specific purpose of studying its initial stages. If we had had a good series of plots for intensive study of ponderosa pine mistletoe we might have been lucky enough to have a needle blight "hot spot" develop on one of them, where we could watch it from its inception.

Multiple use of permanent plots is especially advantageous on areas reserved from logging, where observations can be continued indefinitely. Of course, the investigator must take care that secondary studies do not consume so much time that they interfere with attainment of primary objectives. If this precaution is observed, multiple use of permanent plots can increase appreciably the productivity of our efforts.

We can also make our permanent plots more valuable by making them really permanent, as far as lies within our power. A large minority, if not a majority, of so-called permanent plots are abandoned, for various reasons, after a few years of use. Whether or not the project has been completed, such plots can yield further returns on the investment. To a future investigator, working on another problem, old plots offer the tremendous advantage that records are available of their condition during at least one of the earlier stages of stand development. Anyone who has ever attempted to determine the past progress of a disease on the basis of stand reconstructions will agree, I am sure, that a plot whose history is known, even if only in part, is much more valuable than a plot whose past must be inferred entirely from the evidence on the ground.

Obviously, the material in the files should be quite comprehensive. It is equally important that plots be tied, and boundaries be run and marked, so that they can be relocated with precision after going without maintenance for several decades. For ties, section corners will be preferable to road junctions as long as our woods transportation system continues in its present state of flux. Since the plots will never have been seen by the hypothetical worker who is going to use them in the future, instructions for relocation must be detailed and complete. This sounds like a lot of extra work. Actually, it is little more than should be done as a precaution against loss of valuable plots during periods of national emergency, temporary changes in research priorities, or death, retirement, or transfer of project leaders. On plots where re-examinations are necessary only at five- or ten-year intervals, these measures are largely routine.

Supplementary plots can sometimes be obtained at little cost during disease surveys. For example, in a root rot damage survey on a 395-acre area we made a 100% cruise of 344 samples, each 1/20-acre in extent, taken at regular intervals along the survey lines. All living trees and trees killed by Poria weirii were recorded by species and d.b.h. class. Most of this work was necessary as an objective check on the rest of the survey, which we thought was too subjective. By marking the origins of the survey lines, by running them with a little extra care, and by marking one end of
each sample, we hope we have made it possible to return to this area in
20 or 30 years, repeat the cruise of the samples, and determine fairly
accurately how much damage the root rot has caused, and what its effect
has been on stand composition, during the interim. This method is
inferior in several respects but has two marked advantages over our other
root rot plots: it gives us a practical equivalent of a 17.2-acre plot
at much less expense, and the distribution of the samples will permit a
better estimate of what happens to the entire stand.

I have neither the time nor the temerity to attempt a discussion
of certain other things that should be considered here, such as plot size
as determined by special features of the given disease, and the problems
of striking a balance between superficial work and a too-exhaustive
analysis of a narrow range of conditions. What I have tried to say thus
far can be reduced to a simple syllogism. Plots are expensive. We
can't have as many as we need. Therefore we must make the best of what
we have. Logically, this syllogism is far from perfect, but I don't
think you'll quarrel with the conclusion.

In order not to leave this group in a state of placid harmony,
I'll close by throwing a stone at the sacred cow of randomization. In
agricultural research, where one hill of potatoes is much like another,
and in such things as nursery studies and tests of forest products,
randomization is very useful, but its efficiency in some situations does
not justify indiscriminate, or ritualistic, use of this technique.

If we want any real benefit from randomization, we must replicate,
which usually will involve an increase in number of plots and a conse-
quent reduction in their size. This is open to the objection that many
of our problems can be studied effectively only on plots larger than
we can afford to replicate. Furthermore, reduction of plot size reduces
total plot acreage, since it costs more per acre to establish small
plots than large ones. Our samples are inadequate at best. Reductions
in their extent, for the sake of a problematic gain in interpretation,
are questionable.

Randomization eliminates the effect of personal bias operating
on inter-plot differences. It does not eliminate differences, or even
decrease them. Most of our work is done in an exceedingly variable
universe where it is difficult, if not impossible, to find two plots that
do not differ appreciably in at least one factor likely to influence a
study. We can't reduce the effect of these differences by ignoring their
existence.

In most instances we cannot obtain a basis large enough to permit
both stratification and randomization. The indicated procedure, there-
fore, is to assign treatments or comparisons on the basis of our knowledge
of existing differences, after having made this knowledge as complete as is
practicable.

It is true that experimental error cannot be computed under this
procedure. However, in the problems with which we are concerned at present,
the loss will be more apparent than real. Case studies are perfectly valid even though they do not permit precise evaluation of differences. Randomization will become increasingly useful as progress in our field gradually shifts the emphasis from qualitative to quantitative aspects of problems, and as more adequate financing permits more intensive study. But until that millenium arrives, the investigator should not hesitate to economize effort by loading his experiments, provided that extent and direction of loading be given due weight in his interpretation of results.

I feel rather apologetic about spending this time on a discussion of what might be termed platitudes. My excuse is that there is much to be gained from thoughtful consideration of the obvious. The difficulties under which we labor are obvious, and I recommend them to your attention.
SOME PROBLEMS FACING A PROGRAM OF PERMANENT SAMPLE PLOT STUDIES

By A. C. Molnar

Experience in permanent sample plot studies in British Columbia has been quite limited. Our work in this field can be briefly summarized under the heading of the problems the plots were set up to study.

Poria weirii root rot

a) Disease records were maintained for about 12 years on B.C. Forest Service growth and yield plots at the Cowichan Lake Forest Experiment Station where the disease was first recognized in B.C. This project included a trenching experiment. In recent years the plots fell in the path of thinning experiments or were almost completely denuded by root rot.

b) Three 0.1 acre circular plots established by the Forest Pathology Unit in the Cowichan North Arm Forest specifically to study P. weirii were re-examined a number of times, but have since become involved in a large scale thinning experiment by the B.C. Forest Service. Additional plots, including controls have since been established in this area to follow the effects of the thinning on the disease.

c) In addition a number of B.C. Forest Service growth and yield plots are currently being screened for possible use in Poria weirii research. I am not up to date on the current status of these plots.

White pine blister rust

The progress of blister rust is being studied in five sets of permanent plots established in immature white pine stands throughout the white pine type. These plots are re-examined at five-year intervals.

Pole blight

Pole blight disease progress and sanitation thinning studies are being conducted at two areas in the Nelson Forest District. A total of 54 0.1 acre plots were established in 1950-51 and annual re-examinations have been maintained since that time.

Miscellaneous

Several additional reserve areas have been acquired for inoculation experiments, white pine resistant stock out plantings, and root ecology studies. Periodic re-examinations are involved in all these projects but some of them may not qualify as permanent sample plots in the strictest sense.
POSSIBILITIES OF COOPERATIVE EFFORT IN PERMANENT

I believe there is fairly general agreement among forest pathologists that permanent sample plots provide a very useful (if expensive) tool for the study of forest stands in relation to their environment. Certain types of data may only be obtained by regular periodic measurements. Into this category would fall a great number of progressive and cyclic changes that influence stand development. Accurate qualitative mortality records are lost except where relatively frequent measurements are obtained, for causative factors quickly lose their identity and, particularly in younger stands, dead trees deteriorate rapidly beyond diagnostic value.

That few permanent plot studies have been initiated is due partly to the high cost of establishing and maintaining them and partly to the pressure of work in other directions. Any possibilities available to overcome these handicaps are well worth exploring, assuming that specific problems of sufficient scope and importance exist, which are best suited to permanent plot treatment.

It is quite apparent that a regional laboratory with limited man-power and resources can not embark on an ambitious program of permanent plot studies without some assistance. There are, however, in every forest region a number of agencies engaged in forest research who are held back from permanent sample plot work because of similar handicaps. Active cooperation between such agencies may well be the answer, at least to the cost and man-power problem. While considerable study would be necessary to work out the basis and details of such cooperative effort, I visualize this somewhat along these lines.

Responsibility of Provincial (or State) Forest Service

1. Granting the necessary reserves and ensuring their protection.

2. Establishing the sample plots in cooperation with other participating groups.

3. Taking the initial and subsequent mensurational data which may be taken less frequently than annually.

Responsibility of Forest Pathology Unit

1. Cooperating in the location and establishment of plots.

2. Annual (or less frequent) recording of pathological data.

Responsibility of Forest Entomology Unit

Cooperating, where feasible, in a similar manner to the pathology group.
Other Agencies

Similarly, other research groups such as ecologists, soil researchers, etc., may cooperate beneficially in such an undertaking. (After a number of years a group studying the effects of soil compaction resulting from the heavy feet of the many researchers may gain very enlightening information).

It is necessary to dwell, for a moment at least, on the problems inherent in such cooperative undertakings.

1. Since continuity is the main strength of permanent plot studies, perhaps one of the most important problems is the danger of one or more of the cooperators being forced for various reasons to withdraw from the project after it is well under way. This would increase the burden on the remainder or, if it is not possible to carry on their part, the experiment may be greatly weakened. This danger of course increases with the number of cooperators and the diversity of their affiliation.

2. The selection of an experimental design and sampling basis to meet the requirements of all cooperators may pose some serious problems.

3. The basis upon which cooperative effort is possible may be quite restricting. The types of problems which would be most amenable to such joint studies would seem to be those investigating immature stand development in relation to the overall influences of the various measureable ecological factors including disease development. Where studies are to involve sampling of stands supporting an epiphytotic occurrence of disease the relative stress would be so greatly pathological that it would be difficult to enlist the cooperation of other agencies, not withstanding the fact that the common goal remains a better understanding of forest influences. Furthermore, even from a strictly pathology point of view it should be noted that in areas where diseases have built up to an epiphytotic level the factors causing them are frequently no longer operative and therefore not measureable, or if operative are difficult to isolate. Of course where disease build up occurs in a permanent plot area after records have been started we have the ideal situation to study factors governing their build up.

The choice between permanent and temporary sample plots

A choice between permanent and temporary sample plots must frequently be made and more often than not decision is made in favour of the latter because of the high cost of establishing and maintaining permanent sample plots. In many cases by gathering data from a large number of temporary sample plots which cut across a range of site types and age groups it is possible to build up a stand and disease development picture. It may be well, however, to study and recognize the limitations of such an alternative
Sampling problems involved in permanent sample plots set up to provide disease as well as mensurational and ecological data

It is logical that when studying the relation of disease to the forest certain ecological and mensurational records must be obtained. The accuracy of individual measurements and the rate of sampling must be commensurate with the objectives of the study. It will frequently be found, however, that the rate of sampling necessary for reliable results will vary to a large degree with the factors being measured and the variation with which they occur in the universe being sampled. Thus, under relatively uniform stand conditions a low rate of sampling will provide adequate mensurational data but since disease occurrence and intensity is governed by a great many factors over and above stand composition and site as reflected by tree growth, a much higher rate of sampling may be required to reach the same degree of accuracy for disease records. This would seem to be a very important consideration in the planning stage of a permanent sample plot program.

In closing I will try to drag together some of my disjointed comments. The need to increase permanent plot studies is obvious. While we cannot hope to secure an inventory of permanent plots entirely sufficient to meet our needs, the way may be open to us to do better than we have in the past:

1) By saving money and man-power in a multiple use economy.

2) By enlisting the cooperation of other research groups in our region faced with similar problems and handicaps.

It becomes increasingly apparent to me that we still lack technical know-how to get the best returns for the dollars and sweat invested in plot work. In order to avoid many of the pitfalls encountered in previous ventures some concerted study in permanent sample plot methodology is warranted. It is unreasonable to expect that anyone person or group will come up with all the answers; and for this reason I would go so far as to suggest that an International Committee should be set up to study the problem.
2. Blister Rust Resistance in Western White Pine

SOME PRELIMINARY RESULTS IN TESTING SEEDLING PROGENIES FROM 
CONTROLLED POLLINATIONS AMONG BLISTER RUST RESISTANT WESTERN WHITE PINE 

By R. T. Bingham

This conference has expressed a preference; one in which I concur, that we forego the scheduled trip to the snow-covered Spokane blister rust nursery substituting an informal color-slide visit to that frigid locality. This substitution will allow me to take you via color slides through the entire tree-breeding venture and to provide you with some preliminary results.

The cooperative project in breeding blister rust resistant and otherwise superior western white pine is now in its sixth year of activity. Since reorganization within the Department of Agriculture in January, 1953, cooperators are all from various agencies within the Forest Service. Three publications (1, 2, & 4) cover activities and early results of the breeding work. Accordingly, only some significant new results of resistance testing, a sort of interim report to this Conference, are worth reporting at this time. Work accomplished to date includes selection of 74 apparently rust-resistant pines, vegetative propagation of these selections, production of almost 250 different controlled crosses among various pairs of selections, artificial inoculation of the controlled pollinated seedling lots, and examination of needle spots and rust cankers developing on seedlings progenies from 1950 and 1951 controlled pollinations. The following summary shows the extent of first generation crossing and the time schedule employed in rust resistance testing in western white pine. It is noteworthy that an average of almost 9 crosses per parent (415/47), have been made. Present knowledge that as few as 2 to 4 test tree crosses will probably suffice for resistance testing means that the test program can be much streamlined in the future.

Note that through 1955, results from rust examination are available for only 138 progenies, 99 from the 1950 pollinations, and 39 from the 1951 pollinations. Also that only needle-spot examinations have been completed on the 39 progenies from 1951 pollinations.
<table>
<thead>
<tr>
<th>Pollination Year</th>
<th>Seed Year</th>
<th>Sowing Year (Progeny Trial Year)</th>
<th>Number of Progenies</th>
<th>Years Inoculated</th>
<th>Year Outplanted and First Needle Spot Exams. made (1 yr. after last Inoculation)</th>
<th>Year First Canker Examination made (2 yrs. after last Inoculation)</th>
<th>Number of New Selections Involved</th>
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<tr>
<td>1951</td>
<td>1952</td>
<td>1953</td>
<td>39</td>
<td>'53 &amp; '54</td>
<td>1955</td>
<td>(1956)</td>
<td>4</td>
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<td>1954</td>
<td>1955</td>
<td>(1956)</td>
<td>10</td>
<td></td>
<td></td>
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<tr>
<td><strong>Totals</strong></td>
<td></td>
<td></td>
<td><strong>415</strong></td>
<td></td>
<td></td>
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<td><strong>47</strong></td>
</tr>
</tbody>
</table>

(A series of 30 color transparencies covering all phases of project work was shown here)

Through the medium of slides we have seen the work in selection, vegetative propagation, controlled pollination, artificial inoculation, and other features of nursery practice and handling of seedling progenies. These subjects need no additional explanation. Methods of appraisal of needle spot and rust canker development, however, deserve some additional explanation. Inoculations are made in late September and early October. Approximately 8 months later the first exterior symptoms of blister rust disease (bright yellow needle spots often with a dark yellow-brown eye) begin to appear on seedling foliage. Spots may continue to appear for more than a year but intensification is largely complete in about 10 months or by the end of July in the summer following inoculation. Typical spots of a few progenies have been verified microscopically as accompanied by invading blister rust mycelium. Normally, 7.5 percent of bark cankers appear by late fall of the first season following, 80.4 percent by the second fall season, and 98.2 percent by the third fall season.
Data on 3 features of seedling infection are recorded as follows:
(1) the percentage of seedlings of each progeny having one or more
typical needle spot infections--percent infected, (2) the relative number
of needle spot infections occurring in a 450-needle sample of the foli-
age of seedlings in each progeny--relative number of individual infect-
ion foci or number of lesions, and (3) the percentage of seedlings of each
progeny having one or more typical bark cankers--percent cankered. The
needle spot results must be considered in the light of the possibility
that needle spotting has yet to be proved a reliable index of cankering
to follow. It is possible that the blister rust fungus associated with
certain spots may die prior to reaching the tree bark (for example as
not uncommon in the case of hypersensitive host tissues dying in advance
of virulent, obligate parasites), or that invisible needle infections
may be present and make their initial appearance in the bark. It already
appears that established infections are dying out in the needles and that
a few infections are invisible until they appear as cankers. Otherwise,
the preliminary results indicate that needle spots are good indicators
of blister rust infection. Ultimately this question will resolve itself;
for by the third season following inoculation almost 100 percent of bark
cankers resulting from a given inoculation should be visible.

Turning now to the preliminary results, and beginning with needle
spotting data, let us look at table 1. Fifty-two progenies from the 99
produced in 1950 pollinations are involved. The percent of seedlings
having needle spots, and the relative number of such infection foci
(number of spots per 450-needle sample) is shown for the 52 progenies.
Twenty parent selections as crossed with one or more of 5 test trees are
involved. The test trees employed are merely resistant selection which by
virtue of their fecundity may be crossed with a great number of other
selections. The use of test trees makes results more comparable since
either the male or female parentage of progenies thus compared is constant.
Also included are results from testing some 25 progenies not having at
least 1 test tree parent. These are averaged with test tree progenies
and shown in the all-cross average at the right.

It is evident that the average test tree progeny contains a large
proportion of rust-susceptible seedlings. The average test tree progeny
has 82 percent of its seedlings needle spotted with 187 spots per 450
needles. Control progenies (not shown) averaged 80 percent infected.
Thus it would seem that progenies with infection at or above the 80
percent level should be considered more or less completely susceptible.
It is also evident that test tree progenies of a given parent are rather
consistent in their performance. For instance, progenies of parents 30
and 39 appear to be highly susceptible—from 79 to 94 percent spotted
with 162 to 402 spots per foliage sample—while those of parents 21, 17,
58, and possibly 19 and 24 appear to be to some extent resistant. Parent
21 mated with four test trees produced progenies consistently lower than
average in percent of infection and relative number of infection foci.
The same is true to a lesser extent for selections 17, 58, and possible
19 and 24. Since this is our very first information on transmission of
resistance in first generation crosses we are allowing ourselves to be
somewhat encouraged.
**Table 1**

APPEARENT TRANSMISSION OF BLISTER RUST RESISTANCE BY TWENTY SELECTIONS USED EITHER AS SEED OR POLLEN PARENTS IN FIFTY-TWO CONTROLLED POLLENATED TEST TREE CROSSES MADE IN 1950, TESTED THROUGH FALL, 1954.

(Basic Data, 1954 inspections of 29- to 72-tree progenies showing percent of seedlings in the various progenies having one or more typical blister rust needle spot infection, and number of such typical spots in a 450-needle sample of the foliage of seedlings of the various progenies.)

<table>
<thead>
<tr>
<th>Test Tree Number</th>
<th>Test Tree</th>
<th>All Cross</th>
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<tr>
<td>Parent Number</td>
<td>Inf. %</td>
<td>Infs. %</td>
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<tr>
<td>1</td>
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<tr>
<td>20</td>
<td>91.2</td>
<td>276</td>
</tr>
<tr>
<td>21</td>
<td>46.9</td>
<td>37</td>
</tr>
<tr>
<td>22</td>
<td>81.9</td>
<td>163</td>
</tr>
<tr>
<td>23</td>
<td>82.4</td>
<td>101</td>
</tr>
<tr>
<td>24</td>
<td>X X</td>
<td>X X</td>
</tr>
<tr>
<td>25</td>
<td>X X</td>
<td>90.1</td>
</tr>
<tr>
<td>26</td>
<td>79.2</td>
<td>131</td>
</tr>
<tr>
<td>27</td>
<td>92.3</td>
<td>250</td>
</tr>
<tr>
<td>28</td>
<td>93.9</td>
<td>402</td>
</tr>
<tr>
<td>29</td>
<td>78.3</td>
<td>249</td>
</tr>
<tr>
<td>30</td>
<td>81.7</td>
<td>181.7</td>
</tr>
<tr>
<td>Avgs.</td>
<td>81.7</td>
<td>181.7</td>
</tr>
</tbody>
</table>

1/ Test tree cross made 1951 through 1953 and available for testing until 1955 through 1957.
Performance of progenies produced in chance matings of two parents, both of which are consistent in resistance transmission (i.e., like cross 58x21 of table 1), is even more encouraging. Results of eight such crosses are shown in table 2. They need retesting to firm-up results but for the present can probably be used as a guide for rough estimation of the extent of transmission of factors for resistance in the F₁ generation, as well as to channel future breeding work along more productive lines. Note the percentages of infection ranging from above average to 43 percent below average, and the relative number of infections ranging from 5 to 80 percent below average.

These promising preliminary results from the original 99 progenies are strengthened by the addition of new data this year. Through the most recent examinations, Fall 1955, it still appears that a few parent trees are consistent in transmitting at least some degree of resistance to all of their progenies. Also that a few select progenies of these "transmitters" continue to exhibit an encouraging degree of rust resistance following 1 or 2 heavy, artificial inoculations. The three outstanding progenies from the 1950 controlled pollinations and six other progenies from the 1951 pollinations now appear as shown in table 3. Several points regarding heritable rust resistance in western white pine are brought out by the tabulation.

(1) Among 24 selections having progenies in the 1952 progeny tests, and another 4 selections in the 1953 progeny trials, probably only one parent (#21) is outstanding in resistance transmission. Two other parents are of fair value (#17 and 58) and a few others (#25, 28, and 63) remain at present of questionable value on the basis of data not shown above. Thus the return from testing about 30 selections is about 3 percent in valuable resistance transmitters. To obtain the additional high quality germ plasm needed to put future breeding work on a safer basis a major effort in selection, followed by limited but more efficient pollination and testing procedures is indicated. This work should be undertaken immediately.

(2) The best progenies of the resistance transmitters express inherent resistance the first year following inoculation; both by having 2 to 3 times the percentage of spot-free seedlings as do the controls, and by having only 1/2 to 1/3 as many needle spots per foliage sample as do the controls.

(3) Appearance of needle spots on resistant progenies is often delayed until the second season after inoculation, and by that time the percentage of spot-free seedlings is almost as low as that of the controls. The relative number of needle spots per foliage sample still remains at about 1/2 that in the controls the second year.

(4) In resistant progenies the appearance of cankers is also delayed. By the end of the second season following inoculation 60 percent of infections in natural stands are visible as cankers. In the resistant progenies, however, only 53 percent have appeared, while in the
### Table 2.

Transmission of resistance in crosses wherein both parents are above average in transmitting resistance (through Fall, 1954)

<table>
<thead>
<tr>
<th>Cross</th>
<th>Number Seedlings</th>
<th>Percent Infected</th>
<th>Percent Below Average</th>
<th>Relative Number Spots</th>
<th>Percent Below Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>19x17</td>
<td>69</td>
<td>85</td>
<td>Above Avg.</td>
<td>178</td>
<td>5</td>
</tr>
<tr>
<td>19x21</td>
<td>49</td>
<td>47</td>
<td>43</td>
<td>37</td>
<td>80</td>
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<tr>
<td>19x24</td>
<td>34</td>
<td>82</td>
<td>0</td>
<td>101</td>
<td>16</td>
</tr>
<tr>
<td>19x58</td>
<td>72</td>
<td>76</td>
<td>7</td>
<td>77</td>
<td>59</td>
</tr>
<tr>
<td>21x17</td>
<td>69</td>
<td>55</td>
<td>33</td>
<td>57</td>
<td>70</td>
</tr>
<tr>
<td>58x17</td>
<td>69</td>
<td>80</td>
<td>2</td>
<td>53</td>
<td>72</td>
</tr>
<tr>
<td>58x21</td>
<td>71</td>
<td>62</td>
<td>24</td>
<td>77</td>
<td>59</td>
</tr>
<tr>
<td>58x24</td>
<td>67</td>
<td>69</td>
<td>16</td>
<td>148</td>
<td>21</td>
</tr>
<tr>
<td>Test Tree</td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Gross Avg.</td>
<td>--</td>
<td>82</td>
<td>--</td>
<td>187</td>
<td>--</td>
</tr>
</tbody>
</table>
### TABLE 3


Data from Needle Spot Exams.,
1950 Progenies (3-Yr.-Old Stock
1 Year After Inoculation) | Data from Canker Examinations,
1950 Progenies
(4-Yr.-Old Stock 2 Years After Inoculation)

<table>
<thead>
<tr>
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<tbody>
<tr>
<td>19x21</td>
<td>49</td>
<td>31</td>
<td>67</td>
<td>6</td>
<td>12</td>
<td>51</td>
<td>87</td>
<td>68</td>
<td>54</td>
</tr>
<tr>
<td>21x17</td>
<td>69</td>
<td>45</td>
<td>64</td>
<td>8</td>
<td>14</td>
<td>68</td>
<td>16</td>
<td>68</td>
<td>54</td>
</tr>
<tr>
<td>58x21</td>
<td>71</td>
<td>45</td>
<td>64</td>
<td>8</td>
<td>14</td>
<td>68</td>
<td>16</td>
<td>68</td>
<td>54</td>
</tr>
</tbody>
</table>
| **Avg. of 5** | **272** | **43** | **20** | **167** | **385** | **43** | **11** | **343** | **274** | **271** | **3** | **46** | **12** | (?)0
| Controls | 272       | 43                 | 20                     | 167                       | 385                           | 43                | 11                     | 343               | 274               | 271               | 3                 | 46                | 12                | (?)0

<table>
<thead>
<tr>
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<tbody>
<tr>
<td>19x21</td>
<td>49</td>
<td>31</td>
<td>67</td>
<td>68</td>
<td>16</td>
<td>68</td>
<td>16</td>
<td>68</td>
<td>54</td>
<td>23</td>
</tr>
<tr>
<td>21x17</td>
<td>69</td>
<td>45</td>
<td>64</td>
<td>68</td>
<td>16</td>
<td>68</td>
<td>16</td>
<td>68</td>
<td>54</td>
<td>23</td>
</tr>
<tr>
<td>58x21</td>
<td>71</td>
<td>45</td>
<td>64</td>
<td>68</td>
<td>16</td>
<td>68</td>
<td>16</td>
<td>68</td>
<td>54</td>
<td>23</td>
</tr>
</tbody>
</table>
| **Avg. of 4** | **272** | **43** | **20** | **167** | **385** | **43** | **11** | **343** | **274** | **271** | **3** | **46** | **12** | (?)0
| Controls | 272       | 43                 | 20                     | 167               | 385               | 43                | 11                 | 343               | 274               | 271               | 3                 | 46                | 12                | (?)0

1/ The University of Idaho Canker Development Study based on about 1300 cankers from artificial inoculations showed 80.4% of the cankers visible by fall of the second season after inoculation. Hence, estimated number of trees surviving is calculated by determining the difference between the number of infected (spotted) trees normally having cankers minus the number actually having cankers, then adding this difference to the number of trees still symptom-free.

2/ Estimated percent surviving minus estimated percent controls surviving.
controls very close to the expected 80 percent (79 percent) have appeared. It follows that a number of the infected, or spotted, seedlings in the resistant progenies may never develop cankers. An estimate of this number, added to the number of seedlings remaining entirely symptom-free indicates that about 30 to 40 percent of the seedlings in resistant progenies may survive. A similar estimate, however, shows that about 12 percent of the presumably non-resistant control seedlings will also survive. The latter percentage, 12, would represent the degree of inoculation failure plus the failure of established needle infections to reach bark caused by natural factors other than resistance (i.e. normal needle shedding). If it is removed from the percentages of trees surviving in resistant progenies the resistant progenies remain outstanding with 20 to 30 percent of the seedlings surviving.

Some insight into the possible mechanism of resistance is being gained through continued observation of needle and canker infections in resistant progenies. The symptom picture described above, (fewer spots, more spot free seedlings, plus latent spot and canker development in resistant progenies) and the presence of abnormal cankers seems to indicate an agent, perhaps biochemical, common to both leaf and bark tissues. It seems rather unlikely that resistance results from a number of morphological characters present first in stomata or leaf surface tissues, then in mesophyll and vascular tissues of the leaf, and finally in bark tissues. Work on the biochemical aspects of resistance could yield large returns in simplifying selection and testing work.

After several years progeny testing work three important recommenda-
tions concerning the conduct of the test work can be made. (1) Pro-
cedures for obtaining uniformly heavy artificial inoculation, including certain knowledge of intense sporulation and spore germinability, must be employed. (2) Record keeping must extend to individual seedlings. (3) A good experimental design employing adequate replication and random assignment of replicate position must be maintained from time of inoculation on. In regard to the last two recommendations, we have found that in order to appraise resistance of individual seedlings it is advantageous to be able to identify each in relation to other seedlings immediately adjacent at inoculation time. We have also seen that variation caused by differences in nursery soil fertility or by difference in amount of nursery transplanting to replace missing seedlings of certain progenies can result in variation in size, vigor, and amount of foliage in individual seedlings and entire progenies. These differences are important since blister rust is an obligate parasite where vigor of host is often directly correlated with its susceptibility. The effect of screening of inherently small seedling progenies by surrounding larger progenies seedlings also effects inoculation and makes adequate replication and random replicate positioning essential.

We next come to the process of extracting and retesting the best \( F_1 \) individuals from promising progenies. This is an important process preliminary to proceeding with second generation breeding work. Reinoculations of the most highly resistant individual seedlings from the 1950 trials have been completed. Only a little over 100 class "A" seedlings (generally
large, heavily needled, spot-free, canker-free individuals from portions of the seedbeds known to have been heavily and uniformly inoculated) were extracted from the 7,500 seedlings of the 99 progenies sown in 1952. The majority of the class A seedlings have as one or both parents the resistance transmitters described above. The class A seedlings are now planted so as to facilitate approach grafting. Since this germ plasm is the best yet recovered it will be wise to allow for salvage of several grafts of any seedling which through the reinoculation becomes lethally infected. This test will help to further refine the F1 materials destined for F2 or backcross breeding. It will also help establish whether or not we have immune seedlings in the F1. Besides the class A seedlings we will probably have others which although supporting known needle infections will survive. Thus by next year we can begin extraction of yet another segment of the resistant germ plasm, possibly of an even higher level of resistance. This second group of seedlings will be treated like the class A seedlings discussed above.

Where Do We Go From Here?

Now that we are relatively certain that rust resistance is heritable to a fair degree in the F1 generation, a number of recommendations can be made. We would appreciate receiving comments on these.

(1) After retesting promising individual seedlings from within resistant F1 progenies, get scions of a sufficient number of the best individuals under flower induction treatment toward the production of the F2 and backcrosses, but reserve a similar number for multiplying individual seedlings by conventional grafting methods.

(2) Remake and retest the most promising F1 progenies; first to extract still more highly resistant individuals therefrom, and second to test the practical level of resistance in run-of-the-mill F1 seedling progenies under conditions of natural inoculation occurring in the field. From our present experience it would seem that through repeated, massive, artificial inoculations it may be possible to infect most if not all of the seedlings even in the most resistant F1 progenies. While second generation breeding promises more highly resistant progenies, before abandoning the F1 progenies they should be tested under field conditions. This will determine their usefulness as interim planting stock, possibly filling part of the requirement for planting stock during the interim period while awaiting production and testing of the second generation or first backcross generations. Work in remaking promising crosses was begun in 1955.
Literature Cited


A. FOREST DISEASE SURVEYS - GENERAL

1. Project Title: Forest disease survey in California.
   Project Leader: James W. Kimmey
   Address: California Forest and Range Experiment Station, Berkeley, California.
   Objectives: a. To detect disease epidemics, appraise damage, devise and recommend efficient and effective control measures, and to provide technical services for control projects.
   b. To establish a series of permanent sample plots for each subregion for the determination of annual rate and primary causes of tree mortality and to provide a periodic inventory of all tree diseases in the state.

   Publications: Forest pest conditions in California, 1955 (Mimeoographed report)

B. NONINFECTIOUS DISEASES

None

C. CONE, SEED, and SEEDLING DISEASES

1. Project Title: Disease succession in a Douglas fir nursery.
   Project Leader: D. C. Buckland
   Address: University of British Columbia, Vancouver, B.C.
   Objectives: a. To determine the succession of diseases during one growing season in a Douglas fir nursery.
   b. To determine the pathogenicity of the fungi and bacteria isolated from the seedlings.

   Present Status: The field work for this study has been completed and currently the identification of the organisms isolated from the disease seedlings and the testing of pathogenicity tests are progressing well.

   Publications: None

D. ROOT and SOIL DISEASES OR RELATIONSHIPS

1. Project Title: Root stain disease of eastern white pine.
   Project Leader: Charles D. Leaphart
   Address: Intermountain Forest and Range Experiment Station, Spokane, Washington.

   Objectives: a. To investigate the cause of mortality in an eastern white pine plantation near the Sylvanite Ranger Station, in northwestern Montana.
b. To determine control measures, if any, to eradicate or control the causal agent.

**Present Status:** The mortality is caused by a staining organism, isolated but not identified, which invades the roots near the distal ends and progresses rapidly toward the root collar. Staining of the xylem precedes cambial necrosis by distances up to three feet. Mortality occurs within one or two years of visible crown symptoms, such as foliage discoloration or growth reduction. Infected areas are roughly circular in shape, indicative of root disorders such as those caused by *Poria weirii* and *Fomes annosus*. The disease appears to be of prime importance since the same organism has been isolated from a lodgepole pine root within one of the infection centers. Susceptibility of other species, such as western white pine, western larch, grand fir, and others, must be determined.

**Publications:** None.

2. **Project Title:** Soil moisture studies in relation to the pole blight disease. (Subproject of 54-D-5)

**Project Leader:** Otis L. Copeland, Jr.

**Address:** Intermountain Forest and Range Experiment Station, Spokane, Washington.

**Objective:** To determine the influence of available soil moisture in relation to symptom expression and severity of pole blight on western white pine.

**Present Status:** Soil studies conducted in 1954 indicate a possible relationship between the severity of pole blight and the available water storage capacity of soils. Most of the effective precipitation in the western white pine type occurs before each growing season. This study is designed to determine the effects of an artificially-imposed moisture stress on white pine and, also, to follow the fluctuation of available soil moisture levels in healthy and pole-blighted stands over a period of several years.

**Publications:** None

3. **Project Title:** Mycorrhizal relationships of healthy and pole-blighted western white pine (Subproject of 53-I-2).

**Project Leader:** R. L. Gilbertson

**Address:** College of Forestry, University of Idaho, Moscow, Idaho.

**Objectives:**

a. To determine the types of mycorrhizae found on western white pine and their relative abundance and distribution in healthy and pole-blighted stands.

b. To determine the fungi that form mycorrhizae with western white pine.

c. To determine the relationship of mycorrhizal development to progress of pole blight in individual trees.
d. To compare anatomical features of the mycorrhizae of healthy and pole-blighted western white pine.

Publications: None.

E. FOLIAGE DISEASES

1. Project Title: Ponderosa pine needle blight survey, Oregon and Washington (Subproject of 53-E-1).

Project Leader: John Hunt

Address: Pacific Northwest Forest and Range Experiment Station, Portland, Oregon.

Objective: To determine distribution of the disease, location and extent of damage, and correlations with environmental factors.

Publications: None.

2. Project Title: Elytroderma deformans needle blight of ponderosa pine and Jeffrey pine.

Project Leader: Paul C. Lightle

Address: Institute of Forest Genetics, Placerville, California.

Objectives and Present Status: Due to the fact that this disease is being studied by pathologists in other regions, and that losses caused by it in California are not as severe as in some other parts of the west, study of the disease has been discontinued at this station. Recent attempts to control the disease by the use of fungicidal sprays proved futile. Twig-bagging experiments denote that infection must take place much earlier in the year than has been commonly believed but, still, indicate that the fungus does not penetrate in the twigs and branches.


F. STEM DISEASES - malformations, witches' brooms, dwarf-mistletoes, etc

1. Project Title: Ponderosa pine dwarfmistletoe survey.

Project Leader: John Hunt.

Address: Pacific Northwest Forest and Range Experiment Station, Portland, Oregon.

Objective: To determine distribution patterns of the disease and the extent of damage.

Publications: None.
2. **Project Title:** Chemical control of dwarf mistletoe in ponderosa and jeffrey pines.

   **Project Leader:** Paul C. Lightle

   **Address:** Institute of Forest Genetics, Placerville, California.

   **Objectives:**
   a. To test various herbicides of known composition and concentration for their lethal and other effects on dwarf mistletoe of ponderosa and jeffrey pines.
   
   b. To evaluate the effects of the herbicides on the host.

   c. To determine the time of the year the parasite is the most susceptible to the herbicide.

   **Publications:** None

3. **Project Title:** Studies on dwarf mistletoe of western larch and lodgepole pine.

   **Project Leader:** Charles W. Waters

   **Address:** Montana State University

   **Objective:** To study the nutritional aspects of the parasite with a view to possible application to control measures.

   **Publications:** None

G. **STEM DISEASES - stains and decays**

1. **Project Title:** Correlation of the rate of extension of heart rots in living trees with air temperatures.

   **Project Leader:** Paul C. Lightle

   **Address:** Institute of Forest Genetics, Placerville, California.

   **Objectives:**
   a. To measure and record the internal heartwood temperatures of living trees of various diameters over a 12-month period or longer.

   b. To determine the growth rate of certain heart-rotting fungi at various constant temperatures.

   c. To relate both of the above to the ambient temperature.

   d. To develop a method of determining the rate of decay which can be applied by foresters to trees in a given area.

   **Publications:** None
2. **Project Title:** Cull indicator factors for red fir in the Sierra subregions (Subproject of 53-0-7).

   **Project Leader:** James W. Kimmey

   **Address:** California Forest and Range Experiment Station, Berkeley, California.

   **Objectives:**
   
   a. To collect basic cull data in red fir stands throughout the Sierra subregions for the purpose of checking the application here of the existing cull factors for this species based on studies made in northern California.
   
   b. To supply data for computing new cull factors for the species in the event the existing factors do not apply satisfactorily to red fir in the Sierras.

   **Publications:** None

3. **Project Title:** *Xeromphalina campenella*.

   **Project Leaders:** D. C. Buckland and G. W. Wallis

   **Address:** Forest Biology Laboratory, Victoria, British Columbia.

   **Objectives:**
   
   a. To gain a knowledge of the biology of the fungus
   
   b. To determine the ability of the fungus to cause decay.

   **Present Status:** It is expected that this study will be completed by the spring of 1956. To date the major part of the Biology has been worked out, the distribution of the fungus and its hosts also being completed. The majority of decay tests have been completed.

   **Publications:** None.

4. **Project Title:** Hyphal fusions and their value in identifying various species of Thelephoraceae.

   **Project Leader:** R. J. Bourchier

   **Address:** Forest Biology Laboratory, Calgary, Alberta.

   **Objective:** To determine the feasibility of using the dikaryon hyphal fusion technique in identifying cultures of wood-rotting fungi.

   **Present Status:** A manuscript is in preparation reporting on the effects of pH, temperature, and cultural medium formula on hyphal fusion of *Corticium vellereum*. Of the three factors, culture medium seems to be the only one that has an appreciable effect on hyphal fusions. Continuing work is planned to determine the nature of the substance stimulating hyphal fusions. If negative results can be eliminated, or reduced, by use of such a substance the method could hold promise.

   **Publications:** Manuscript in preparation

-91-
H. STEM DISEASES - rusts and cankers.

1. Project Title: Inoculation of sugar pine seedlings to expedite the acquisition of rust-resistant trees.

   Project Leader: Cooperative assignment; U. S. Forest Service and B. R. C. Methods Development Unit.

   Address: Pacific Northwest Forest and Range Experiment Station, Portland, and California Forest and Range Experiment Station, Berkeley.

   Objectives: a. To speed the acquisition of rust-resistant sugar pine for planting and breeding stock.

   b. The testing of sugar pine seedlings from 28 lots of seed which had been collected throughout the commercial range of sugar pine to determine whether there was any difference in susceptibility to blister rust of the various seed lots.

   Present status: Exploratory work already conducted by the Division of Forest Genetics (Calif. For. and Range Exp. Sta.) on grafting and rooting of cuttings indicates that sugar pine will be a difficult species to mass produce by these means. Sugar pine seldom produces significant numbers of flowers until about 40 years old and produces seed at about 60 years of age. Selection of rust-resistant sugar pines for grafting or controlled pollination work is not too reliable for sugar pine growing under natural conditions has not been exposed to the rust sufficiently long to provide a reliable measure of resistance on the part of individual trees. At the present time there are only about seven known resistant trees in California.

   Publications: None

2. Project Title: Test of fungicides to inhibit blister rust development on the leaves of ribes bushes. (Subproject of 54-H-7)

   Project Leader: B. R. C. Methods Development Unit personnel (as assigned)

   Objective: a. To test certain fungicides (Fermate, Captan, and Actidione) on rusted ribes to see if one could be found that would either prevent or inhibit rust development.

   Present Status: This work was undertaken in part to answer questions received at the Washington office of the U. S. Forest Service and elsewhere about the possibility of treating horticultural groups of ribes bushes with a fungicide instead of eradicating them, and in part to serve the interests of control work in the far west. In some areas where currants and gooseberries are grown as a fruit crop heavy infection by rust has seriously reduced both quantity and quality of berries. In the actual control programme fungicides that would prevent rust development on pine and ribes might be used for nursery protection and in short term protection of young pines on recent cut-over or on plantations in areas of clearcut and burn.
3. Project Title: The differentiation of telia of Cronartium ribicola and C. occidentale (Subproject of 54-H-6).

Project Leader: T. E. Rawlins

Address: University of California, Berkeley

Objectives: a. To develop new methods for the differentiation of telia of C. ribicola and C. occidentale for more positive identification

b. To develop a method of identification that can be used in the field by blister rust scouts.

Publications: None.

4. Project Title: Effect of microclimatic conditions on the distribution and spread of white pine blister rust in California (Subproject of 54-H-2).

Project Leader: James W. Kimmey

Address: California Forest and Range Experiment Station, Berkeley

Objectives: a. To determine microclimatic conditions necessary for the establishment, development, and spread of white pine blister rust in the Sierras.

b. To describe the typical characteristics of and to evaluate the rust hazard of different types of areas so that the degree of ribes eradication required for adequate control of the disease may be judged in the field by control personnel.

Publications: None

I. WILT AND BLIGHT DISEASES

1. Project Title: Effect of pole blight on growth and mortality in white pine thinning plots (Subproject of 53-I-1).

Project Leader: Donald P. Graham

Address: Intermountain Forest and Range Experiment Station, Spokane, Washington.

Objective: To determine the effect of pole blight on growth and mortality of two sets of white pine thinning plots from two different locations.

Present Status: These plots were established and thinned in 1933 and 1934 before the presence of pole blight in the stands. The plots consist of 14 one-quarter-acre areas including seven which are thinned and seven which have not been thinned. All plots have been examined at five-year intervals. The plots afford an opportunity to observe diameter and volume growth and mortality prior to the presence of pole blight and
after the disease appeared in the stands.

Publications: None.

2. Project Title: Effect of silvicultural measures on the white pine pole blight disease (Subproject 53-I-1).

Project Leader: Donald P. Graham

Address: Intermountain Forest and Range Experiment Station, Spokane, Washington.

Objectives: a. To compare the progress of pole blight in stands in which diseased pines are removed with its progress in adjacent uncut stands.

b. To determine the growth of species which occupy an area upon removal of the overstory by disease, logging, or both.

Present Status: The tests consist of three treatments arranged in a Latin Square of nine plots of approximately nine acres each. The three treatments used were:

a. Check (no cutting)
b. Cut merchantable pole-blighted pines
c. Cut merchantable pole-blighted pines and poison all non-merchantable pines.

Each of the nine plots was sampled by one-fifth-acre circular plots at the time of cutting in 1952 and again in 1955. The plots were established in 1950.

Publications: None

J. DEFECTS AND DECAYS OF FOREST PRODUCTS, DEAD TIMBER, SLASH, ETC.

None

K. OTHER STUDIES

1. Project Title: Studies on propagation of disease-resistant strains of *Pinus monticola* by vegetative methods (Subproject of 54-K-2).

Project Leader: Charles W. Waters

Address: Montana State University, Missoula, Montana

Objective: To propagate, by vegetative means, disease resistant strains of western white pine.

Present Status: Western white pine is an exceedingly refractory species insofar as vegetative propagation is concerned. Some success has been achieved in that it has been possible to secure approximately 30% rooting by both the cuttings and aerial methods. The project is continuing and at present intensive histological studies are being made of the effects of hormone applications on callusing and root initials.

Publications: None.
2. Project Title: Residual stand studies

Project Leader: A. K. Parker

Address: Forest Biology Laboratory, Victoria.

Objective: To investigate pathological problems in cut-over spruce-balsam stands with particular reference to scar damage.

Publications: None.

APPENDIX II

CHANGES IN OR TERMINATIONS OF PROJECTS


Summary of findings: A total of 152 diseases on 21 tree species and 12 forest diseases on 10 other forest plants have been collected, identified, and incorporated into a pathological herbarium at Juneau and added to the national herbarium in Beltsville. Each disease has been classified as to type of damage caused and its general abundance in the Territory.

Publications: To be published

2. (53-G-6) Cull and Breakage Factors for Southeast Alaska

Summary of findings: Based on 560 dissected trees from eight localities in southeast Alaska, both flat factors and indicator factors were computed in board feet and cubic feet to a fixed top diameter for Sitka spruce, western hemlock and western red cedar.

Publications: To be published.

3. (53-J-3) Deterioration of Fire-killed Timber in California.

Summary of findings: Fungi and insects are the principal agents causing deterioration. Most decay was caused by Fomes pinicola, Polyporus volvatus, and F. abietinus in descending order of importance. Small trees deteriorate more quickly than large ones. Of the five species studied, white fir deteriorates the fastest and Douglas fir the slowest. Few white fir are salvable after 3-4 years. After five years few ponderosa and jeffrey pines are suitable for salvage. Large logs of sugar pine may be profitably salvaged for 10 or more years and large Douglas fir logs 15-20 years after the fire. Other than species and size, environment and rate of growth are the principal factors affecting rate of deterioration.

APPENDIX III
NEW AND MODIFIED TECHNIQUES


Submitted by: V. J. Nordin

Address: Forest Biology Laboratory, Calgary, Alberta.

Technique: Apparently no one investigates or conducts the same pattern or number of isolates from a decay infection. This procedure may have to vary somewhat with local situations but a practice which has proven very satisfactory is a vertical pattern of isolations made in the advanced decay, and a number of horizontal isolations at two-inch intervals beyond the cone of visible discoloration.

The rewards of methodical and intensive culturing frequently appear questionable, especially in cases where a myriad of organisms are accumulated. Generally, however, a better picture of the microflora of the tree results. Greater confidence may be obtained in associating decay in specific instances and the significance of the association of non-basidiomycetes with decay pathogens may receive clarification.

2. Practical Hints for Plot Work.

Submitted by: T. W. Childs

Address: Pacific Northwest Forest and Range Experiment Station, Portland, Oregon.

Techniques: a. Tree tags: Smooth the bark to about half of its original thickness, then staple the tags (with both tag and staples in a vertical position to keep them from tearing out as tree circumference increases). Use staples not quite long enough to reach the cambium. This practice will eliminate future danger to saws from embedded nails, and we expect it to save much of the time now spent on frequent pulling and resetting of nails in fast-growing trees.

We are experimenting with stapling of tags to main stems of seedlings and saplings. If otherwise satisfactory, this will save time both in tagging and in making subsequent examinations.

b. Painted numbers on all trees, or on "key" trees, will speed examinations. Where crowns are to be examined, paint the number on the side from which the examiner can best view the crown. This not only saves a lot of walking but also keeps differences in viewpoint from reducing the comparability of successive examinations.

Yellow paint is best on Douglas-fir, and aluminum paint on ponderosa pine. Small pressurized cans of paint save more than enough time to compensate for their extra cost. Painted numbers last longer if bark is first smoothed as deeply as possible without injuring the cambium.

c. Corners and camera hubs.- Stakes are much more conspicuous if tops are dipped in "traffic yellow" paint. This paint is...
cheap and durable, and stands out very well even in forest types where natural yellows are common.

To facilitate replacement of obliterated corners, scratch the stake designation and distance on a piece of strip aluminum, and staple this flasher, facing the stake, at ground line on a nearby tree (preferably on smoothed bark and in a crotch between large roots). Flashers facing the stake and at eye level on several surrounding trees will help examiners keep themselves located. Animals have destroyed a number of our flashers in some localities, but their destructiveness appears to decrease as the novelty wears off. Even when the flasher has disappeared, enough staples usually remain to indicate its original location.

d. Lines.—Mark trees adjacent to boundary and block lines with a splash of paint on the side of the tree toward the line. These marks can be made rapidly with a paint gun, and last for many years (some of ours, made with a brush in 1939, are still visible). Time saved in examinations more than compensates for the cost of line-marking.

e. Miscellaneous.—It is sometimes advantageous to mark certain trees with flashers giving data for use in future examinations. On dead trees, staple flashers to the wood so they won’t be lost when bark is sloughed. On living trees, staple one side of the flasher at the extreme edge so it won’t be pulled apart by tree growth.

3. A Punch Card Form for the Recording of Heavy Data.

Submitted by: V. J. Nordin

Address: Forest Biology Laboratory, Calgary, Alberta.

Technique: Denyer and Etheridge of the Saskatoon and Calgary Laboratories of Forest Pathology recently adapted the information required in decay studies to a punch card to facilitate the analysis of data. This form contains the logarithmic tree form on one side and the basic data on fungi and volumes, etc., on the other. It is now employed by at least two laboratories in Canada and is recommended for decay investigations generally.

APPENDIX IV

PUBLICATIONS


1b. __________________ Red rot of ponderosa pine in the Southwest. Station Paper No. 15, 11 pp. 1954. (53-G-1)


16a. Hawksworth, F. G. Dwarf mistletoe survey of the Mescalero Indian Reservation. Rocky Mountain Forest & Range Expt. Sta. Rept. 15 pp. plus 31 tables, 4 fig. (Mimeographed) 1954. (54-F-3 and Sub of 53-F-2)

16b. Observations on the age of lodgepole pine tissues susceptible to infection of *Arceuthobium americanum*. Phytopathology 44(9): 552. 1954. (53-F-2)


APPENDIX V

MINUTES—BUSINESS MEETING

THIRD WESTERN INTERNATIONAL FOREST DISEASE WORK CONFERENCE

The business meeting of the Third Western International Forest Disease Work Conference was opened at 10:30 a.m., December 1, 1955 in the Desert Hotel, Spokane, Washington, Chairman Vidar J. Nordin presiding.

Discussion was held on the general subject of meetings in order to give the executive committee some basis to discuss with the entomologists opportunities for joint meetings.

Motion: That the meetings of the Western International Forest Disease Work Conference be held annually, moved by R. J. Bouchier and seconded by P. C. Lightle. Carried.
Motion: That the executive committee be empowered to discuss the subject of and to choose locales for annual meetings, moved by D. C. Buckland and seconded by J. R. Hansbrough, Carried.

The meeting adjourned until 1:30 p.m., December 2, when the general business meeting of the conference was opened by Chairman Nordin.

Minutes of the 1954 meeting were read by the Secretary. Motion was made by C. D. Leaphart and seconded by A. C. Molnar that the minutes be approved as read. Carried.

The financial statement prepared by the Secretary was read as follows:

<table>
<thead>
<tr>
<th>Credits - collections</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Registration fees</td>
<td>35 at $3.00</td>
<td>$105.00</td>
</tr>
<tr>
<td>Banquet dinner charges, 40 at 2.50</td>
<td>$100.00</td>
<td>$205.00</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Debits - disbursements</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Social hour charges</td>
<td>52.05</td>
</tr>
<tr>
<td>Banquet license</td>
<td>1.00</td>
</tr>
<tr>
<td>Room rentals</td>
<td>20.00</td>
</tr>
<tr>
<td>Projector rental</td>
<td>5.00</td>
</tr>
<tr>
<td>Dinners, 41 at $2.25</td>
<td>92.25</td>
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<tr>
<td>Tax on dinners</td>
<td>3.08</td>
</tr>
<tr>
<td>Gratuities</td>
<td>15.00</td>
</tr>
</tbody>
</table>

Balance - to be used for secretarial expenses $16.62

The subject of standardizing the proceedings of the conference was discussed. Consideration was given to submission and listing of publications, revising and proposing a standard system for listing projects, setting up a permanent filing system for conference affairs and proceedings, etc.

Motion: That C. D. Leaphart chair a committee, to be selected by him, to study and resolve a scheme for standardizing and revising the proceedings of this Conference, moved by P. C. Lightle and seconded by D. C. Buckland. Carried.

Further discussions were held as follows on the Conference meetings:

1. Location - Fort Collins, Denver, Albuquerque, or El Paso
2. Registration fees
3. Recommendations for future meetings.

Motion: That a registration fee be established but that the amount be determined and fixed annually by the executive committee, moved by A. W. Slipp and seconded by W. W. Wagener. Carried.

Motion: That the 1956 meeting be held in El Paso, moved by R. E. Foster and seconded by P. C. Lightle. Carried.
In a discussion of distributing L. S. Gill's paper on chemical control of dwarfmistletoe, it was suggested that it be given limited distribution (to those requesting it) to be handled by Gill. It was suggested that he handle distribution to the home offices of the various chemical companies.

Discussion was held on assigning necessary committees to formulate and propose ideas on uniformity in certain studies.

Motion: That a committee be set up to investigate the permanent sample plot problems and that it include representatives from all regions in the West with A. C. Molnar as chairman, moved by D. C. Buckland and seconded by T. W. Childs. Carried.

Motion: That a committee be set up to consider standardization of measurement data in decay studies with R. E. Foster to chairman the group, moved by W. W. Wagener and seconded by J. L. Mielke. Carried.

The subject of affiliation with other groups, particularly the Northwest Scientific Association, and of participation in our Conference by foresters and others, other than pathologists, received considerable discussion. It was the general feeling that we should limit our membership to pathologists. By doing so, we would be able to maintain the purpose for which our Conference was organized—that of being solely a work conference immune to pressure groups. However, it was felt that we benefit greatly from participation in our discussion by foresters and others who wish to attend our meetings and that we should encourage such attendance as affiliates as guests of our group.

Motion: That the Western International Forest Disease Work Conference does not affiliate with the Northwest Scientific Association, moved by O. L. Copeland and seconded by E. Wright. Carried.

Chairman Nordin announced that nominations were open for chairman of the 1956 meeting. L. S. Gill was nominated by G. P. Thomas. Moved by A. W. Porter and seconded by E. Wright that nominations be closed. L. S. Gill was elected by acclamation.

Chairman Nordin then opened nominations for secretary for the 1956 meeting. Ross W. Davidson was nominated by A. C. Molnar. Moved by P. C. Lightle and seconded by D. R. Miller that nominations be closed. Ross W. Davidson was elected by acclamation.

Chairman Nordin thanked the members for the splendid cooperation received during the year in helping to make this conference a success. He then turned the meeting over to the new chairman who welcomed the group to El Paso.

The conference and business meeting was adjourned at 3:25 p.m., December 2, 1955.