PROCEEDINGS OF THE 31st ANNUAL WESTERN INTERNATIONAL FOREST DISEASE WORK CONFERENCE

Coeur d' Alene, Idaho
August 1983

Proceedings of the 31st Annual Western International Forest Disease Work Conference

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Compiled by:
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Foreward

"Sooner or later you will do what your boss wants you to do" admonished John Laut in his 'address from the chair.' John went on to remind us that, as forest pathologists, the public is our boss and we need to educate our boss. Thus, this year's conference was delivered into the ready hands of WIFDWC participants on Tuesday morning, August 22, in the convention center of North Shore Hotel in Coeur d'Alene, Idaho.

Tom Richards, President of Idaho Forest Industries, delivered an enlightening keynote address on the status and future of the forest products industry.

Project progress reports, root disease and dwarf mistletoe committee meetings, a panel discussion, several special papers including a slide-tape program on *Phellinus weirii* prepared by Larry Weir, a poster session with seven presentations, a tree nursery tour, a day-long field trip, banquet aboard the Mish-a-Nock on Lake Coeur d'Alene, culminated by the business on Friday morning all made for a varied and informative conference.

The formal program was somewhat altered when a panel on "Disease surveys, impact assessment, computer mapping, and data management" headed by Ed Wood was canceled. The other panel members had been unable to attend. Ed graciously volunteered to speak on the subject for the alloted 2 hours. The audience declined (not wanting to impose) and instead heard impromptu discussions with Federal and State FPM groups on design of their respective disease and insect training programs.

Bill White, who intended to serve on Ed's panel, forwarded his excellent paper on Impact Assessment which has been included in these proceedings.

Eighty-two registered for the conference with 26 nonregistered guests: A good showing for these budget-troubled times.

Executive committee for the 31st WIFDWC:

John Laut . . Chairman

Sue Dubreuil. Secretary-Treasurer

Dave Johnson. Program Chairman (replacing Randy Fuller)

Local arrangements: John Schwandt

Other arrangements:

Nursery tour	Conference field trip	Preconference field trip
Bob James	John Schwandt	Bob James
	Jim Byler	Sue Dubreuil
	Sue Dubreuil	Oscar Dooling
	Bob James	John Schwandt
	Oscar Dooling	
	Cathy Stewart	

Many thanks to Linda Hastie for typing, including the numerous lists, while trying to cajole a sophisticatedly uncooperative computer into taking instructions. My thanks also to Carma Gilligan for paste-up and for catching many of my numerous errors and to John Schwandt for giving me so many photographs to chose from -- some are destined to be classics.

OPENING REMARKS

John G. Laut

Chairman

Fifteen years ago we met in this same Hotel. To my knowledge, it is the first time in our 37-year history that we have been able to do that! In fact, with the exception of Victoria - we've never been invited back to any other city! Until now - welcome to Coeur d'Alene.

As I look back through our recent history, I find a recurring thread - we worry about ourselves! Some quotes (abstracts) from my predecessors in this chair -

1975 - Stu Whitney - "do not hide our light under a bushel." We must get out beyond talking to ourselves.

1976 - Lew Roth - asked "What are we worth to the land manager?" and noted that our capa-abilities have not flowered. Keynot speaker Ed Schroeder - State Forester, Oregon told us we must "publicize what diseases do to our resources."

1979 - Lew Roth in a special address on Past, Present & Future of Forest Pathology, noted today - ATTRITION -- if we want a tomorrow - we must rebuild our credibility.

1981 - The theme for the meeting was Is It Worth It?

1982 - Bloomberg in his remarks from the chair pointed out it was politically a bad year for pathologists and decried our lack of political and professional assertiveness. We "owe it to our profession to extol the importance of the discipline in the solution of forestry problems."

Was it an accident that a later panel presentation was entitled "Cry Wolf?"

- We must talk with others - Who?

- What are we worth - To Whom?

- Publicize - To Whom?

- Rebuild our credibility - With Who?

- Is it (are we) worth it? - To Who?

- Assert ourselves and our profession - Where?

- Extol our importance - To Whom?

Attrition - To Us!

Politically - a poor year - Why?

Politics of forest pathology, politics of pest management. Politics - never for scientists??? Politics is the science or art of administering and managing public or state affairs.

Forests - trees - provide a public good regardless of ownership. The backyard shade tree - ultimate private ownership - affects the neighbors, the neighborhood and the community. Forests are public affairs. Administering or managing a forest, regardless of your employer, is a political activity.

Forest pathology - pest management must be politicized and publicized - by who? By YOU!

We are important but we must prove it. How many of you have in the last year visited or corresponded directly with your local delegates to Congress or your M.P.? (How many know who they are?) - With your State representative or provincial MLA? What about your local reporters - press or electronic media? Do you know them? At the least - how many have personally prepared a canned media release for distribution - describing your work and the public impact it is or will or might have?

We all work for the public. If the public knows what you do and favors what you do, they can ensure you a future. A favorite adage of mine is "Sooner or later you will do what your boss wants you to do." The trick is to educate your boss so that his wants or needs and your activity are the same. If you don't blow your own horn, you will get run over.

We must build our own credibility!

Enough philosophizing - we are here essentially to talk among ourselves. Participate! Listen and discuss. Youth - don't be awed, grey beards - be tolerant. Above all - enjoy yourselves.

It is my pleasure to declare this 31st Western International Forest Disease Work Conference open.

Keynote Address

Tom Richards, President of Idaho Forest Industries, a Coeur d'Alene-based company, gave an informative presentation on impact of the economic recession on the forest products industry. His message was well delivered and, at times, surprising. He pointed out that 60 to 70 percent of forest products come from small woodland owners. The bulk of production in northern Idaho is sawmill products rather than pulp and is, therefore, closely tied to U.S. housing markets which have declined in the current recession.

He said the recession will have served to streamline those companies which survive. We can have a reasonably healthy timber industry with our "belts tightened." Some small, weak companies will close, marginal mills of big companies have and will continue to close, but the remaining industry will be healthy.

He also predicted a slight "boom" in the 1990's because of people who should have built in the 1980's saving to build in the next decade. However, he cautioned that companies would do well not to "put the fat back on" in response to the somewhat better times ahead.

NURSERY DISEASES

Jack R. Sutherland - Moderator

Forest nursery seedling diseases lower seedling quality and quantity, thereby causing both direct (e.g., fewer seedlings, pesticide costs) and indirect (e.g., altering reforestation plans, affecting seedling survival) monetary losses. Nursery-acquired diseases such as western gall rust may also cause subsequent losses in the field or disseminate pathogens to uninfested areas. A recent consideration is that disease (and other pests) presence often requires pesticide usage which concerns nursery workers and tree planters.

The purpose of today's discussion is to review some of the current diseases and their management in Northwest nurseries.

Soil-borne diseases and top-killing are important in bareroot nurseries and Sally Cooley and Phil Hamm will update us there. Recent changes in the technology of growing seedlings, especially the development of container nurseries, have changed the relative overall importance of soil-borne diseases vis-a-vis total seedling production while increasing the significance of seed-borne and shoot diseases, e.g., gray mould (*Botrytis cinerea*). I will review two seed-borne diseases and Bob James will discuss disease management in container nurseries. Nursery pests (especially diseases) will continue to be important in the future not only because increasing numbers of seedlings will be grown using new techniques, but also because foresters will want seedling species that have been seldom, if ever, produced. Production of *Abies* spp. (for example) is increasing rapidly in British Columbia nurseries to fulfill the demand for reforestation at high elevations where trees are now, by necessity, being harvested. Rapid progress is being made in tree improvement and pathologists will be increasingly asked to prevent or minimize losses of these very valuable seeds and seedlings. I believe that this latter factor will eventually lead to the demise of directly sowing seeds in bareroot beds where damping-off losses are often high. Two other aspects of growing seedlings that are changing rapidly are the roles played by private growers and pest managers. In the future neither growing nor protecting seedlings will remain the sole responsibility of governments. Fred McElroy will describe his experience as a private pest management consultant.

Jack R. Sutherland is Research Scientist and Project Leader (Regeneration Pests), Pacific Forest Research Centre, Canadian Forestry Service, 506 W. Burnside Rd., Victoria, B.C. V8Z 1M5.

TWO SEED-BORNE DISEASES OF CONIFERS: THE SEED OR COLD FUNGUS AND SIROCOCCUS BLIGHT

Jack R. Sutherland

Most of the information on these diseases has been summarized by Sutherland and Van Eerden (1980).

The first of these fungi, Caloscypha fulgens (imperfect state Geniculodendron pyriforme) goes by the common names of the cold or seed (S) fungus. The pathogen was first identified in 1964 (Epners, 1964) as causing pre-emergence losses in Ontario forest nurseries. Salt (1974) in Britain, then isolated it from spruce seeds imported from western North America. Since then it has been isolated from conifer seeds in British Columbia (Sutherland, 1979; Sutherland and Woods, 1978), Oregon and Washington (Harvey, 1980) and Idaho (Wicklow-Howard and Skujins, 1980). Paden et al. (1978) connected the perfect and imperfect states. The fungus kills a wide variety of conifer seeds (Salt 1974), but to date it has been found to be seed-borne only on spruces, Douglas-fir and true fir, probably because the cones of the first two open at maturity while true fir cones often disintegrate and the pieces are collected from the ground. Infection occurs when cones contact the forest duff where the fungus lives (Ginns, 1975). Under coastal British Columbia conditions, spruce cones can contact infested duff for about 2 weeks before the seeds become infected (Sutherland, 1981). While seedlots originating from ground- and slash-picked cones frequently contain the pathogen, it is most prevalent in squirrel-cache-collected seedlots (Sutherland, 1979). Disease incidence within infested seedlots usually ranges from 1-5%, but sometimes up to 60% of the seeds are diseased. Presence and percentage incidence can be estimated by plating surface-sterilized (30% H_2O_2 for 30 min) seeds onto water agar (Sutherland et al., 1978) or by determining the presence and activity of alkaline phosphatase (Sutherland, et al. 1981). Within infested seedlots even low levels of C. fulgens are important because the fungus spreads during stratification, afterward on seeds cold-stored before sowing, and in seedbeds and container cavities. Presence of the fungus may be indicated in seedlots that germinate poorer when stratified. Cool, damp conditions favor disease spread in seedbeds (Epners, 1964; Salt, 1974) and container cavities (Thomson et al., 1983) as does number of seeds sown per cavity. Normally, the fungus enters seeds via several "bore holes" in the seedcoat (Woods et al., 1982) and the contents are mummified rather than rotted (Epners, 1964). Once germination begins seeds are immune from the fungus and so failure of germinants to emerge is the only indication of the disease, i.e., without retrieving diseased seeds. Disease prevention is recommended and includes not collecting cones that have contacted duff for extended periods, particularly during wet periods, and prohibiting cone collection from squirrel caches. Under normal circumstances the fungus does not spread farther when cones are stored outdoors in bags on well-ventilated racks prior to seed extraction or in stored (near freezing, low moisture) seedlots. Seed orchard seedlots should not contain the fungus because these cones are hand picked. A fungicide added to the stratification water of infested seedlots prevents fungus spread and a fungicide treatment of seeds will reduce pre-emergence losses in bareroot beds (Epners, 1964). In the latter, infested seedlots should always be spring sown, preferably after soil temperatures are high enough to promote rapid germination.

Sirococcus blight, S. strobilinus, is another seed-borne disease in Northwest nurseries (Sutherland et al., 1981). Mainly spruces are affected and although the fungus has been isolated from western hemlock seeds, disease of this seedling species in the nursery has not been clearly related to seed-borne inoculum. Although Sirococcus-infested seedlots are certainly sown in bareroot nurseries, disease occurrence can be related only to seed-borne inoculum in container nurseries where environmental conditions are probably more favorable. Sirococcus blight on bareroot seedlings, e.g., lodgepole pine, usually can be traced to inoculum from nearby larger trees. On container-grown spruce, the first indication of the disease is killing of recently-emerged germinants, frequently before the seedcoat is shed, and presence of pycnia on the hypocotyl. Probably these seedlings provide the primary source of inoculum from which secondary disease spread occurs. On older (up to 2 months) seedlings, killing progresses from the base upward on both primary and young secondary needles until the entire seedling is killed; again, pycnia form on the dead tissues. Because the disease is seed-borne, damage is most severe on specific seedlots (infested ones) and these often have a history of disease occurrence. Since cool, moist and overcast weather favor Sirococcus blight, it is more common in Coastal than Interior nurseries. In outdoor container nurseries disease control is further complicated because the rainy weather which favors the disease also leaches nutrients from the growing medium and those must be replaced via the overhead irrigation system, prolonging the humid conditions. Fungicides must be applied regularly to protect the new portions of the rapidly growing seedlings. Fungicide applications concern both nursery workers and tree planters. Nursery managers should be informed prior to sowing infested seedlots so that sprays can be applied at the first indication of the disease to help reduce secondary spread via water splashed conidia. In greenhouses, humidity should be reduced and temperature and lighting (where practical) increased, all in conjunction with fungicide application. When the time and mode of Sirococcus infection of seeds are known (work in progress) it should be possible to prevent occurrence of seed-borne Sirococcus.

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TOP BLIGHT IN PACIFIC NORTHWEST CONIFER NURSERIES

Sally J. Cooley

Top blight of Douglas-fir in Pacific Northwest nurseries is a newly recognized problem causing variable but often substantial seedling losses. The term "top blight" encompasses a wide range of symptoms where branches or the top of the seedling are killed and delineated from healthy parts of the tree by a constriction or canker. Sometimes a discrete canker will form on the stem with living tissue above and below it which, in fact, may be an earlier stage preceeding top death. Location of cankers range from groundline to within 1 or 2 inches of the top of seedlings. The first evidence of cankering is wilting and chlorosis in parts of seedling distal to canker. Symptoms are first seen in the late summer, fall, or winter of the first year or in the early spring of the second year. Mortality continues through the spring and summer of the second year.

Top blight was first noticed in the late spring of 1980 in several Willamette Valley and western Washington bareroot nurseries in 2-0 Douglas-fir. Variable amounts of top blight have occurred since then in these nurseries. This summer, for example, large numbers of 1-0 Douglas-fir are dying due to top blight where very few were affected in 1981 and 1982. Coastal Oregon nurseries suffered considerable damage from top blight in 1981, 1982, and 1983. In 1981, losses in the 2-0 Douglas-fir crop in two Oregon and Washington nurseries were 25 percent and 30 percent, respectively. A disease with some similarities to top blight, Phoma tip blight and canker, has been reported in northern California on Douglas-fir, red fir, and white fir (Kliejunas and Allison 1982; Smith, unpublished). In the early 1970's, Phoma blight was identified on 1-0 Douglas-fir, primarily affecting the needles and usually associated with a soil collar; since 1979, Phoma tip blight and canker has been found on 1- and 2-year-old red and white fir. Losses from Phoma tip blight and canker in northern California (at Humboldt Nursery) in 1982 were 90% and 38% in red fir and white fir, respectively (Kliejunas, unpublished).

At the present time, it is unclear if top blight of Douglas-fir in the Pacific Northwest is caused by disease organisms or abiotic agents. Isolations from top blighted seedlings have yielded a number of fungi, some normally pathogenic on other hosts or in other parts of seedlings. Fungi isolated most frequently from cankered tissue have been *Phoma* spp., *Phomopsis* spp., and *Fusarium roseum*. Often, a predominance of either *Phoma* (+ *Phomopsis*) or *Fusarium* occurs which may not be consistent to each nursery over time. For example, primarily *Fusarium* spp. have been isolated from the latest outbreak (summer, 1983) of top blight in Oregon and Washington nurseries, although *Phoma* had been recovered most frequently from these nurseries previously. Other fungi such as *Penicillium*, *Trichoderma*, *Alternaria*, *Botrytis*, *Stemphylium*, and *Epicoccum* also have been recovered frequently; although these fungi should not be totally disregarded, they probably are associated with top blight strictly as saprophytes, invading tissue previously infected and killed by other organisms or agents.

Inoculation trials were made in 1981 to determine the capability of some of the isolated top blight organisms to cause cankers and mortality (Cooley 1983). Containerized 1-0 Douglas-fir seedlings were inoculated with two *Phoma* isolates and two *Fusarium roseum* isolates. Mycelial plugs (placed on stem next to cambium) and spore suspensions (sprayed onto foliage and stem following needle removal to create small wounds) were two inoculation techniques used. After 6 weeks, cankers were caused by one *Phoma* isolate and one *Fusarium* isolate when seedlings were inoculated with agar plugs. No infection occurred with spore inoculations. Further pathogenicity tests will be carried out by research forest pathologists at Oregon State University.

There is some speculation that cultural practices or environmental pressures may sensitize, weaken, or even injure seedlings to the extent that fungi such as *Phoma* are able to invade the weakened tissue and cause cankers. Herbicides, root pruning, soil splash, and lack of water have all been suggested as factors or agents which could predispose seedlings to infection.

Control of top blight has been attempted through sanitation and fungicide applications. Rogueing blighted seedlings has not significantly reduced disease and disease spread in the nurseries where it has been systematically tested. Although the number of live seedlings was no different with various fungicide treatments, initiation of new infections on Douglas-fir was dramatically reduced with captafol (1-2 lbs.a.i./acre) and chlorothalonil (2-4 lbs./a.i./ acre) at the Weyerhaeuser Nursery at Mima (Washington) during fungicide trials in 1982. Seedlings were sprayed eight times between February and June, and number of infections was tallied in September. Other fungicides which have been tested or used operationally with variable results (usually not effective) are benomyl, captan, Zyban, and iprodione. Good Phoma tip blight control in the 1970's was achieved on Douglas-fir at Humboldt Nursery with applications of captafol, chlorothalonil, and copper oxychloride sulfate at 2- to 4-week intervals from October to April (Smith, unpublished). Several different fungicides including triadimefon, vinclozolin, mancozeb, and triforine were tested on red fir at Humboldt Nursery this year; none of the fungicides gave adequate control of Phoma tip blight and canker. In summary, most fungicides have been ineffective and no one fungicide gives consistently good control.

Work on top blight of Douglas-fir in Pacific Northwest nurseries has been initiated by researchers at Oregon State University. Their objectives are to identify the biotic causal agent(s) associated with top blight via isolations and pathogenicity tests, define symptomology associated with each agent, determine the epidemiology of the organisms involved, and identify any predisposing factors. From this information, they hope that predictions of top blight occurrence can be made and control measures implemented in a timely manner so as to be effective. In vitro tests for fungicide sensitivity of *Phoma* and *Fusarium* isolates are being carried out by Forest Pest Management (USDA, FS) in Portland, Oregon. Mycelial growth and spore germination of selected isolates from top-blighted Douglas-fir will be measured on fungicide-amended media.

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Phytophthora Root Rot in Bare Root Tree Nurseries of the Pacific Northwest

Philip B. Hamm and Everett M. Hansen, Department of Botany & Plant Pathology, Oregon State University, Corvallis, Oregon 97331.

Phytophthora root rot in Pacific Northwest bare root nurseries was first reported in 1975, causing severe damage to Douglas-fir (*Pseudotsuga menziesii*) (14). Four species of *Phytophthora* were identified; *P. cinnamomi*, *P. cryptogea*, *P. drechsleri* and a previously unidentified species, designated *P. sp* 1 [now called *P. pseudotsuga* (9)]. Subsequent to that report, additional *Phytophthora* and host species were identified or found to be susceptible. These included *P. cactorum* (8) and two morphological and pathologically distinct groups of *P. megasperma* (6, 7, 10), and western hemlock (*Tsuga heterophylla*), several true fir species [white (*Abies concolor*), Shasta red fir (*A. magnifica* var. *Shastensis*), noble (*A. procera*) and two species of pine [sugar (*Pinus lambertiana*) and ponderosa (*P. ponderosa*)] were found susceptible. More than one *Phytophthora* species was occasionally isolated from a single infected tree.

Typically, symptoms of *Phytophthora* infection are not exhibited until trees are approaching their second growing season, or following transplanting. Pre and post-emergence damping off can occur during the first year, but this is more commonly thought to be due to *Fusarium* and *Pythium* species. By early spring of their second year, root rotted trees begin to yellow as they break dormancy. Damage is often concentrated in low areas in the field where surface water accumulated during the long (4-5 months) wet and mild winter. By early summer most of these trees will have died. Seedlings not as severely infected commonly exhibit delayed bud break, poor elongation of the new terminal and lateral shoots (giving a bottle brush appearance) and chlorosis. Seedlings with light infection may not express top symptoms. Below ground, *Phytophthora* symptoms are easily recognized. In trees moderately to severely rotted, root systems noticeably lack typical numbers of lateral roots and have a shortened tap root; less severely rotted trees may only possess a few "shortened" roots. Light scraping of the cortex, to expose the cambial region in roots of diseased trees, reveals the characteristic reddish brown of *Phytophthora* infected tissue in contrast to white, healthy tissue further up the stem.

With the exception of *P. cinnamomi*, these species of *Phytophthora* are quite adapted to the environmental conditions found in the Pacific Northwest nurseries. Roth and Kulman (15) concluded that *P. cinnamomi* was not a threat to the Douglas-fir forests of the region due to its requirement for simultaneous warm soil temperatures and high soil moisture. This requirement apparently holds for nurseries as well since *P. cinnamomi* has only been recovered once. In contrast, the remaining *Phytophthora* species apparently survive well in nurseries under wet and mild conditions. The moist, cool winters favor production of sporangia, which in turn develop and release zoospores. While dissemination of zoospores in the soil is quite limited (3), widespread infection can result if surface water accumulates or water or equipment moves through contaminated blocks. Zoospores are chemothropic and are attracted to exudates from susceptible hosts roots. This may explain why root pruned transplants are sometimes severely damaged. Zoospore production and dissemination decreases with declining soil moisture, though recent information (P. B. Hamm, S. J. Cooley and E. M. Hansen, unpublished) seems to indicate root rot severity of infected trees continues to increase until irrigation is decreased in late July and August. Phytophthora can be isolated from live, infected seedlings throughout the year. Long-term survival apparently is by resistant structures (e.g., oogonia, chlamydospores) in soil or in infected roots or dead trees (12). Fortunately other factors must be limiting in forest sites since these Phytophthora species have not spread from outplanted infected stock (12).

Susceptibility of the tree species grown in Northwest nurseries varies as does the aggressiveness of the Phytophthora species. P. cinnamomi, where conditions allow, and P. cryptogea have been shown to be highly aggressive to most native conifers (Table 1, 8); P. megasperma Group 1 (6, 10) is generally less

Table 1. Root rot potential of Pacific Northwest conifers to six species of Phytophthora tree species.

Phytophthora Species	Douglas-fir	Noble fir	Pacific Silver fir	Shasta red fir	White fir	Ponderosa pine	Sugar pine	Western hemlock	Western red cedar
P. cactorum	W	H	W	H	W	W	W	M	I
P. cinnamomi	H	H	H	H	H	W	M	H	I
P. crytogea	H	H	H	H	M	M	M	H	I
P. drechsleri	W	W	W	M	W	W	W	H	I
P. megasperma									
Group 1	H	M	M	H	M	W	M	H	I
Group 2	W	W	W	W	W	W	W	W	I
P. pseudotsugae	W	W	W	W	W	W	W	M	I

[1]based on pathogenicity tests by planting healthy seedlings into artificially infested soil for 8-10 weeks.

[2]H = highly rotted
M = moderately rotted
W = weakly rotted
I = immune

aggressive but more damaging than *P. drechslei* and *P. cactorum*, while *P. megasperma* Group 2 (6, 10) and *P. pseudotsugae* are generally only weakly aggressive. Shasta red fir and western hemlock seedlings are generally the most susceptible to *Phytophthora* infection, followed by Douglas-fir, noble, Pacific silver and white fir, then sugar and ponderosa pine. Western red cedar was undamaged by any *Phytophthora* species in our tests (8). This information is based on controlled *in vitro* testing for a period of 8-10 weeks. The extended length of time trees are grown in nurseries (1-3 years), coupled with a long favorable environment, can allow even the least aggressive of these fungal species to cause significant damage in a nursery setting.

Host specificity was generally not evident, except that isolates of *P. cryptogea* from sugar pine caused significantly greater root rot on that host than did isolates of the same species from other hosts (8). Although both groups of *P. megasperma* are pathogenic on most conifers tested, *P. megasperma* Group 1 is pathogenic only to conifers while *P. megasperma* Group 2 also attacks alfalfa (10).

Control of *Phytophthora* root rot is best achieved through cultured practices. Most forest nurseries have been established on old agricultural ground with diverse cropping histories, poorly drained soils, and low organic matter. Since some of these *Phytophthora* species are common agricultural pathogens, it is possible they were present prior to nursery establishment (4). Had forest sites been picked, many of the *Phytophthora* problems may have been avoided. Most serious problems occur where soils are water saturated for long periods. Improving the drainage by underground tiling, bed forming, and land planning will significantly lessen the area and severity of root rot. Planting more tolerant or immune species in high risk areas is also an option. Care must also be taken to prevent spread of *Phytophthora* during either intra- or inter-nursery movement. Equipment cleaning should be a standard practice before moving into another block. Culls should never be used as a soil amendment, but taken off site for disposal. Bare root seedlings should never be transplanted between nurseries, a practice responsible for contaminating many nurseries with multiple species of *Phytophthora*.

Chemical control of *Phytophthora*, until recently, has generally not been effective. Soil fumigation, using methyl bromide and chloropicrin at 300-400 lbs/AC is a common practice the fall prior to spring sowing. Adequate treatment is usually not obtained in *Phytophthora* prone areas, however, because of heavy wet soils. Even if good fumigation is achieved by correctly controlling the many variables (e.g., soil temperature, moisture and soil preparation), reestablishment of the pathogen can occur readily by water movement during heavy rains. Fumigation is also expensive ($1200-1400/acre) and could be responsible for stunting problems randomly found in nursery beds. Fungicides have not been effective due to their low activity toward *Phytophthora* until the recent introduction of Subdue (metalaxal 2EC). Bruck and Kenerly (1) have reported good control of *Phytophthora* root rot of Frasier fir in North Carolina, based on reduced tree mortality and inability to isolate the fungus after treatments. More recently, the efficacy of this material was tested in Northwest nurseries with mixed results. Heavily diseased trees responded well, but *Phytophthora* could be recovered at high frequencies even after three applications (5). This condition presents a two-fold problem: (I) healthy appearing but still infected seedlings will spread the fungus to noninfected areas at transplanting and may have reduced survival chances in the field (12); and (II) continued exposure to multiple treatments could increase the chances of developing fungicide resistance in the pathogen. Some strains of Phytophthora have already been shown to have some level of tolerance to Subdue (2, 13). Use of this material can be quite helpful but should be limited to late fall or early spring application only, when a possible Phytophthora problem is confirmed, and only in high risk areas. Chronic Phytophthora areas or "low spots" should be avoided when planting to prevent the need for continued fungicide application. Metalaxyl should be reserved for preventative treatment in emergencies. Control of chronic disease areas can only be achieved by improved soil management.

During the eight years since Phytophthora was first reported in the Pacific Northwest bare root nurseries, these fungi have been directly responsible for the closure of one large nursery and substantial reduction in production in several others. Dollar loss also occurs through poor survival of infected seedlings outplanted to forest sites (12). More basic and applied research is needed to better understand the biology of these organisms and to developed integrated control strategies. This point is exemplified by the recent extensive losses in three newly established commercial nurseries, identifying Phytophthora root rot as an ongoing production problem.

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DISEASES OF CONTAINERIZED CONIFER SEEDLINGS

Robert L. James[1]

INTRODUCTION

Three major groups of diseases affect containerized conifer seedlings in western North America. These include damping-off/root diseases, Sirococcus shoot blight, and Botrytis blight. Several other diseases may occur (table 1), but their effects are generally much less severe than these three. Diseases of containerized conifers may proliferate in a greenhouse environment because seedling growing conditions are often conducive to disease development. Therefore, disease impact can usually be reduced by altering environmental factors to reduce pathogen buildup or host susceptibility.

Damping-off/Root Diseases

These diseases are caused primarily by four genera of fungi: *Pythium*, *Phytophthora*, *Rhizoctonia*, and *Fusarium*. Significant losses usually occur only when seed is infested with these pathogens; the typical container growing medium of vermiculite, peat, or perlite is generally not contaminated with these pathogens (Peterson, 1974).

Water mold fungi (*Pythium*, *Phytophthora*) are favored by high humidity regimes produced in greenhouses. Most damping-off occurs before or within a few days of seedling emergence (Sutherland and

Table 1.--Minor diseases of containerized conifer seedlings in western North America.

Name of disease	Causal organism(s)	Hosts	Reference
Needle tip dieback	*Alternaria* spp.	Engelmann spruce white spruce	Sutherland and van Eerden (1980)
Shoot tip blight	*Diplodia pinea* (Desm.) Kickx.	Ponderosa pine	Schweitzer and Sinclair (1976)
Fusarium top blight	*Fusarium oxysporum* von Schlechtendahl ex Fr.	Douglas-fir pines	Sutherland and van Eerden (1980)
Shoot blight	*Pestalotia* spp.	Amabilis fir western larch	Sutherland and van Eerden (1980)
Needle dieback	*Phoma* spp.	Pines spruce western hemlock western redcedar	Sutherland and van Eerden (1980)
Leader/branch dieback	*Sclerophoma* (=*Phoma*) *pityophila* (Corda) Hohn.	Lodgepole pine Sitka spruce	Miller (1974)

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van Eerden 1980). However, Pythium and Fusarium can also cause damage after seedlings are 1 or more months old (Peterson 1974). Late damage by Pythium is especially common when high humidity is maintained for extended periods. Nitrogen fertilization during periods of seedling susceptibility may also increase losses from damping-off (Peterson 1974).

Phytophthora is usually an important pathogen only on woody ornamentals in containerized operations (Peterson 1974). Apparently, the growing medium used in forest seedling production provides enough air space and proper moisture drainage to discourage Phytophthora.

Fusarium is a common seed inhabitant of many conifer species (Sutherland and van Eerden 1980). If present, Fusarium rapidly colonizes young seedling tissues and may mask primary infection by other fungi, such as Pythium (Peterson 1974).

Damping-off and root diseases are best controlled by providing clean seed, non-contaminated growing media, and environmental manipulations within greenhouses during periods of maximum seedling susceptibility. Applications of fungicides after damping-off becomes evident is usually not very effective (Peterson 1974). Seed treatment with fungicides has usually eliminated pathogens on seed, but has also frequently reduced seedling emergence (Peterson 1974). Other problems with fungicide seed treatment include lack of prolonged seed protection because of leaching of fungicides, resistant fungal populations may exist, and most fungicides are not effective against all potential damping-off fungi (Sutherland and van Eerden 1980). Because of these problems, many growers have emphasized treatment of seed in a continuous running water bath for at least 48 hours or use of hydrogen peroxide. Incorporating fungicides into growing media to improve seedling survival has been tested (Pawuk and Barnett 1974) and may be used if media is suspected of being contaminated. Improving air circulation and reducing watering during periods of high seedling susceptibility may also help reduce losses from damping-off or root diseases.

Sirococcus Shoot Blight

Sirococcus strobilinus Pruess is commonly associated with tip dieback and mortality of young pine seedlings grown within seedbeds of nurseries where cool, wet conditions prevail (Schwandt 1981; Smith 1973). However, in British Columbia nurseries, the disease is more prevalent on container-grown conifers (Sutherland, Lock and Farris, 1981). Sirococcus occurs rarely in container operations in the United States.

Sirococcus shoot blight is particularly damaging in British Columbia coastal nurseries where it primarily affects seedlings of Sitka spruce (Picea sitchensis (Bong.) Carr.), white spruce (P. glauca (Moench) Voss), and Engelmann spruce (P. engelmannii Parry (Sutherland, Lock and Farris 1981). Other hosts include lodgepole pine (Pinus contorta Dougl.), ponderosa pine (Pinus ponderosa Laws.) and occasionally western hemlock (Tsuga heterophylla (Raf.) Sarg.). The pathogen is often seedborne on spruce, but apparently not on the other host species (Sutherland, Lock and Farris 1981).

Infection within greenhouses occurs via water-splashed spores originating from seedborne diseased spruce or diseased trees adjacent to the greenhouses (Sutherland and van Eerden 1980). On spruce, symptoms usually appear first on random seedlings within about 6 weeks of emergence (Sutherland, Lock and Benson 1982). Symptoms appear between the period before the seedcoat is shed through to secondary needle appearance and leader development. On species where the fungus is not seedborne, such as lodgepole pine, damage tends to appear after secondary needles have developed (Sutherland, Lock and Farris 1981). Primary needles are initially killed from the base upward, followed by the remainder of the epicotyl and above-ground portions of the hypocotyl. Killed seedlings are desiccated, light to reddish-brown, and usually remain upright. Black pycnidia often form on the inner base of diseased needles (Sutherland and van Eerden 1980).

Research indicates that sometimes more than 3 percent of the seed in specific spruce seedlots may be infected with S. strobilinus (Sutherland, Lock and Farris 1981). The fungus occurs in endosperm and embryo tissues of seeds with either shrunken or normal-appearing contents. Because most spruce seeds are presently collected from wild trees, there are no practical methods for reducing or preventing seed infection.

Incidence of Sirococcus shoot blight should diminish as disease-free seed produced in seed orchards becomes prevalent (Sutherland and van Eerden 1980). Nursery managers should be alerted before sowing seedlots with severe blight history so that remedial action can be taken at the first appearance of the disease. Such action includes roguing diseased seedlings and applying protective fungicides. Other recommendations include reducing relative humidity, increasing temperatures in cool greenhouses, and providing supplemental light during cloudy periods (Sutherland and van Eerden 1980).

Botrytis Blight

Grey mold caused by Botrytis cinerea (Fr.) Pers. is usually the most damaging disease of containerized conifers. The disease is especially severe in greenhouses, where conditions are ideal for infection by and buildup of the fungus (James, Woo and Myers 1982; McCain 1978).

Although many conifer species are susceptible, greatest damage has been reported on Douglas-fir (Pseudotsuga menziesii (Mirb.) Franco), western hemlock, lodgepole pine, and spruce in British Columbia (Sutherland and van Eerden 1980), western larch (Larix occidentalis Nutt), lodgepole pine, and Engelmann spruce in northern Idaho and northwestern Montana (James and Genz 1983; James and Gilligan 1983; James, Woo and Myers 1982), lodgepole pine, Scots pine (Pinus sylvestris L.), Engelmann spruce and blue spruce (Picea pungens Engelm.) in Colorado (Gillman and James 1980), and giant sequoia (Sequoiadendron giganteum (Lindl.) Buchholz) and Douglas-fir in California (McCain and Smith 1978).

Twenty-two species of Botrytis have been described (Jarvis 1980b). However, the most common and the species which affects conifer seedlings is B. cinerea. This species has a wide host range with more than 200 hosts described. Other Botrytis species are more specialized in their pathogenicity and have narrower host ranges (Jarvis 1980b).

A typical disease cycle for B. cinerea is shown in figure 1. The sexual stage of the fungis is Botryotinia fuckeliana (DeBary) Whetzel, which has been found frequently in nature (Lorbeer 1980). Apothecia produced from overwintering sclerotia give rise to ascospores which may initiate infection (Jarvis 1980a). However, conidia are responsible for most spread and buildup of the disease within greenhouses.

Initial infection in greenhouses occurs from nearby infected plants or plant debris and sclerotia (Coley-Smith 1980; McCain 1978). Conidia are dry and dispersed in air currents or sometimes in water (Jarvis 1980a). Conidial dispersal occurs primarily when the relative humidity is rising or falling rapidly (Jarvis 1980a). Presence of free moisture on foliage for several hours is necessary for infection (Blakeman 1980). Prolonged cool temperatures of about 13-14° C are also necessary. Germinating conidia form appressoria on the surface of leaves and germ tubes penetrate directly through the cuticle (Blakeman 1980). Wounded or necrotic host tissues are quickly infected and colonized (Sutherland and van Eerden 1980).

Within the disease cycle, latency may occur following conidial dispersal or infection (fig. 1). However, when inoculum is abundant and environmental and host susceptibility conditions are conducive, "aggressive pathogenicity" occurs (Jarvis 1980a). Conducive environmental conditions include high relative humidity, cool temperatures, and free surface moisture on foliage. Host susceptibility factors include nutrient imbalances and presence of senescent tissues for saprophytic buildup of inoculum (Sutherland and Van Eerden 1980). When conditions for infection are ideal and inoculum abundant, latent periods are short and epidemics may occur quickly (Jarvis 1980a).

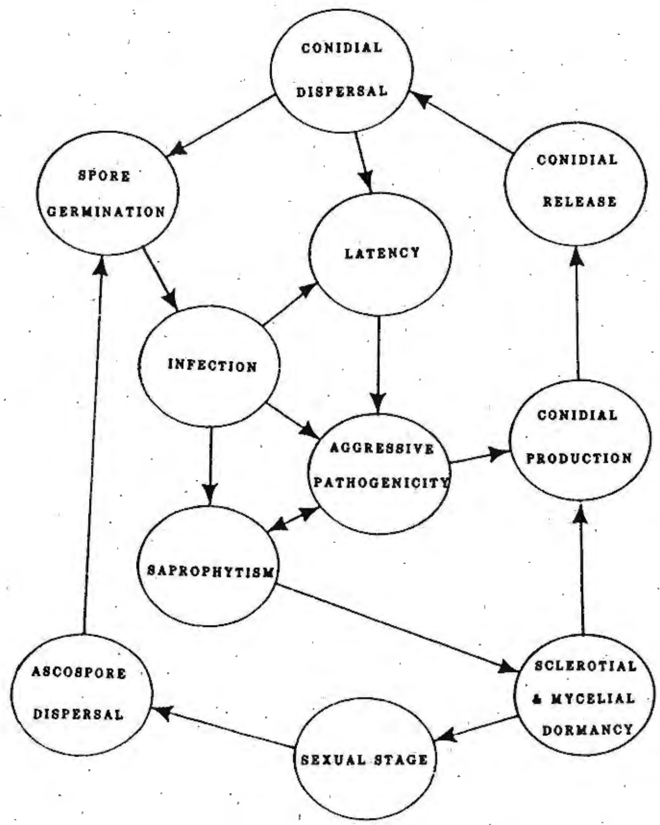

Figure 1. Disease cycle of Botrytis cinerea (adapted from Jarvis 1980a).

Resting structures (sclerotia) often form after the growth phase of the fungus or following seedling mortality (Coley-Smith 1980). Sclerota persist in soil, plant debris, or on greenhouse benches and floors; they produce either sexual or asexual spores upon germination (fig. 1).

Symptoms of Botrytis infection usually become apparent when crowns of containerized conifers begin to close; affected seedlings usually occur in isolated pockets (Gillman and James 1980; James, Woo and Myers 1982). The fungus usually first attacks senescent tissues at the base of seedlings and then spreads to surrounding live host material (Smith, McCain and Srago 1973; Sutherland and Van Eerden 1980). Symptoms on infected seedlings include needle necrosis, twig and stem lesions and mortality.

Controlling Botrytis blight is difficult because the pathogen is capable of attacking all plant parts at almost any stage of their growth and in storage (Maude 1980). The best approach to control is to avoid conditions that are best suited for disease buildup. This includes controlling stocking by reducing density to improve air circulation among seedlings (Cooley 1981), which means producing fewer trees per unit area. However, this is compensated by higher quality, disease-free seedlings. If possible, irrigation should also be limited (Cooley 1981). Adding a drying agent to irrigation water to expedite drying of foliage may also result in reduced levels of infection. Fertilization should also be properly controlled. For example, too much fertilizer may cause seedlings to burn, providing ideal infection courts for Botrytis (Sutherland and van Eerden 1980), and too little fertilizer may stress seedlings making them more susceptible to infection (Cooley 1981). Another important practice to reduce losses from Botrytis blight is sanitation, aimed primarily at reducing inoculum. Sanitation practices include periodic removal of infected plants and plant debris and cleaning greenhouse benches and floors with a surface sterilant between crops (Cooley 1981). Potential inoculum sources outside greenhouses, especially those upwind, should be eliminated when possible.

As containerized production of conifers has increased, Botrytis blight has become more important. As a result, many growers have had to rely on fungicides to keep losses at acceptable levels. Several fungicides either used operationally or showing promise for future use, are listed in table 2.

Certain fungicides have special advantages, such as low cost, ease of handling, and improved efficacy. However, most recommendations for fungicide use stress rotating chemicals to discourage tolerance buildup in Botrytis populations (Cooley 1981; Gillman and James 1980; James and Gilligan 1983). Tolerance has been demonstrated for most of the commonly used fungicides, especially if they have been used repeatedly. When tolerance develops, alternative chemicals are usually tried. However, unless precautions are taken, Botrytis may become resistant to these new chemicals. For example, two new fungicides (iprodione and vinclozolin) developed for other crops, have shown promise in controlling Botrytis in conifer greenhouses (James, Woo and Myers 1982; Powell 1982). However, laboratory studies indicate that several isolates of Botrytis can quickly develop tolerance to both of these chemicals even at high concentrations (James, unpublished). Therefore, apparently none of the chemicals currently available can be considered completely effective against all Botrytis strains likely to be encountered. As a result, fungicide usage should be limited to the minimum amounts necessary for effective disease control. Also, rotated fungicides should have different modes of action, i.e., systemic chemicals alternated with broad spectrum protectants (Cooley 1981; James and Gilligan 1983). Combining proper cultural practices with prudent use of fungicides is usually necessary for effective control of Botrytis blight.

Table 2. Fungicides used to control Botrytis blight in containerized conifer nurseries.

Fungicide	Trade name	Manufacturer	Chemical name
benomyl	Benlate® Tersan 1991® Benomyl	 Dupont Lilly Miller	Methyl-1-(butylcarbamoyl)-2 benzimidazole carbamate
captan	Captan Orthocide®	Stauffer Chevron	N-[(Trichloromethyl)thio]-4-cyclohexene-1, 2-dicarboximide
chlorothalonil	Bravo 500® Daconil 2787®	Diamond Shamrock	Tetrachloroisophthalonitrile
copper	Tri-Basic®	CP Chemical Phelps Dodge Cities Service	Basic copper sulfate
dicloran	Botran®	Tuco	2,6-Dichloro-4-nitroaniline
ferbam	Carbamate	Dupont	Ferric dimethyldithiocarbamate
iprodione	Chipco 26019®	Rhone-Poulenc	3(3,5-dichlorophenyl)-N-(1-methylethyl)-2,4-dioxo-1-imidazolidinecarboximide
mancozeb	Fore®	Dupont	Contains 16% maganese, 2% zinc and 62% ethylene bisdithiocarbamate ion/maganese ethylene bisdithiocarbamate plus zinc ion
maneb	Dithane M-22®	Rhom & Haas	Manganese ethylene bisdithiocarbamate
thiophanate-methyl	Zyban®	Mallinckrodt	dimethyl[(1,2-phenylene)bis(iminocarbonothioyl)]bis(carbamate)
thiram	Thylate®	Dupont	Tetramethylthiuram disulfide
vinclozolin	Ronilan® Ornalin®	BASF	3-(3,5-dichlorophenyl)-5-ethenyl-5-methyl-2,4-oxazolidinedion
zineb	Zineb Dithon Z78®	Rhom & Haas	Zinc ethylenebisdithio-carbamate

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THE ROLE OF THE CONSULTANT IN NURSERY PEST MANAGEMENT

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Con.sult'ant, n. One who gives professional advice or services." Peninsu-Lab acts in both of these capacities to assist nursery superintendents in making pest management decisions. We not only advise nursery personnel on the best approaches to pest management in their nursery, but we also back our diagnoses with laboratory analysis.

The consultant fills a unique roll in the dissemination of information and advice to the nurseryman. The researcher develops the information regarding a pest or problem which is passed on to the grower through the extension specialist. Because of time and economic restraints, neither the researcher nor the specialist is able to deal with the grower on an extended or in-depth basis.

The consultant, however, can work with the nurseryman at any level of intensity from analysis of a single pest sample to a comprehensive on-site monitoring pest management program. He has the flexibility to cut across lines of research specialization to work out solutions to problems unique to an individual nursery. Further, because of an ongoing acquaintance with the nursery and its specific conditions and requirements, he can offer recommendations which will enable the nurseryman to avoid problems. If an unexpected problem does occur, the consultant is familiar with the situation in the nursery and can more quickly come to a solution. The consultant can train the nursery personnel to look for the early symptoms of a problem, and after confirmation by the consultant, steps can be quickly taken to prevent further development.

ORGANIZATION & SERVICES OF PENINSU-LAB

Historically, Peninsu-Lab was established in 1977 as a nematode diagnostic laboratory. It has gradually expanded into many areas of pest management to meet the needs of the various industries. Presently, PL serves agriculture, forestry and ornamental industries in any situation related to pests and diseases.

PL started a program of forest nursery consulting in 1979 in response to a request from a large nursery association. We now serve them with a full PMP, along with most of the larger nurseries in WA and OR. At one end of the scale some nurseries send in 1-2 samples per year for disease diagnosis, while at the other end a visit is made to the nursery biweekly, the entire crop inspected for pests, diseases and potential problems, and a written report and recommendations are provided. In the latter case extensive written and photographic records are kept of field observations to assist in future management decisions.

PL is staffed by Fred McElroy, PhD, (Nematologist, Pathologist), Olaf Riberio, PhD (Pathologist, Soilborne Disease Specialist), and Judy Bigelow, BS (Microbiologist), Marilyn McElroy, Executive Secretary. We have a fully equipped lab for pest and disease work, greenhouses and land for growth trials and experimental work. A microcomputer for data storage, report preparation and transmission has just been added to keep the lab to state-of-the-art capabilities.

PL'S APPROACH TO NURSERY PM

The first step in working with a new client is to evaluate their current management program. Obvious corrections are made immediately, but usually the program is evaluated through the first season and changes made as needed. During the season, detailed observations are made regarding pests and diseases in the nursery, their location, frequency and severity, etc. Most observations are backed by photographic records. Where possible, nursery overflights are made and photographs taken of problem areas. This not only helps evaluate the extent of a current problem but serves as a record for future management decisions, especially in cases where the problem is soil related.

Other aids are also used to assist in anticipating problems. Where insects are important, pheromone traps are used to determine when and where a problem will occur and to properly time sprays if needed. Weather stations, from a simple recording thermograph to more complex computerized stations, are also used both to anticipate and to assist in determining the cause of problems.

One of the most important items that we insist upon is the maintenance of complete and accurate records of all nursery operations. This includes all chemical applications, irrigations, tillage operations, etc., and the associated environmental conditions. Once this is in effect, it considerably reduces the amount of time necessary to solve a growth problem. Approximately 75% of the problems encountered, whether biotic or abiotic in origin, are in some way related to management practices. Quite often the simple act of having the nursery workers record this information is enough to avert several problems. The nursery superintendent soon learns this is saving consulting costs. While this tends to reduce the initial monetary return to PL, it increases the acceptance of recommendations, and builds a longer lasting relationship and reputation.

When pest and disease problems can be anticipated, a minimal routine spray program is recommended and revised as conditions dictate. If unanticipated problems arise correct diagnosis is the key, and this is always backed by laboratory analysis. The only exceptions are in cases where a delay caused by the long time needed to isolate the organism would result in significant mortality. In those cases diagnosis and recommendations are made on the basis of signs and symptoms of the condition. Otherwise the organism is correctly identified in the lab and control directed specifically toward that organism. We try to minimize the use of biocides and broad spectrum pesticides unless our lab results indicate a need for these chemicals.

To further help us in making proper chemical recommendations we frequently run pesticide tolerance tests on the organism in question. The organism (e.g. Botrytis) is isolated from several areas of the nursery in question. These isolates are tested in the lab against all of the pesticides currently registered for the organism. The most effective chemicals are then put into a rotational program and evaluated under field conditions. An ineffective chemical is removed from the program but the remaining chemicals are still kept on a rotating basis to minimize tolerance development by the organism.

At the end of the season, a Quality Control Program is established to determine the effectiveness of the PMP and to point out areas requiring further investigation. Photographs and description of pests and diseases are provided to help nurserymen and QC auditors look for affected seedlings as they are lifted and packed. Records of losses due to various types of problems are kept and evaluated to determine changes needed in the PMP for the next season. These records are also valuable in sorting out planting problems which may show up later.

Often problems are encountered in a nursery that are unique to that nursery and for which there are no routine answers. In those cases PL sets up ad hoc or "Problem solving" research programs. These vary from a few tests during one season to long-term programs which may carry over several seasons, i.e. "whatever it takes to get an answer but no more". Such tests may involve development of alternative management practices or obtaining data for the registration of a needed pesticide. Both of the above are presently in operation in different nurseries.

RELATIONSHIPS

All of the above require an ongoing, interactive relationship with anyone having anything to do with the production of forest nursery seedlings. This includes nurserymen, foresters, extension specialists, researchers, chemical company representatives, etc. One of the critical and often misunderstood areas of interaction is the relationship between the consultant and extension and research. For many years the consultant was considered a "black sheep" of the professional society. In some cases this was justified for there were many "consultants" who were ill-qualified to serve the grower and created more problems than were solved. That picture has changed dramatically in recent years to the point where today consultants have excellent qualifications and serve an important function both to the grower and to the research and extension community.

The consultant can be a great source of field information and can actually assist in data collection on a research project. Epidemiological data relating to frequency and distribution of pests and diseases can be obtained. Because the consultant operates at the field level to implement PMPs, he is able to evaluate their efficacy and pass this information on to those involved. He can also provide the background information on problems requiring further research.

As stated previously the consultant does fill a unique and key roll between the grower, researcher and extension specialist. It is a complementary role, one that "...serves to fill out or complete." The end result allows the nurseryman to produce a better, healthier crop more economically.

The critical role of environment in nursery pathology

by Thomas D. Landis
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ABSTRACT

Tree seedlings are particularly sensitive to environmental influences and many biotic and abiotic diseases are caused or aggravated by the nursery environment. Many seedling disorders can be directly attributed to nursery site deficiencies that are a consequence of poor site selection. Because no nursery site is perfect, nursery managers have had to develop special cultural practices to overcome serious site problems. The ideal growing environment of a greenhouse is also conducive to many nursery pests that are not a problem in a conventional bareroot nursery. The container nursery manager is able to produce tree seedlings in a short time but these seedlings must be morphologically well-balanced and properly hardened before outplanting.

INTRODUCTION

The importance of the environment in the etiology of disease is well established. Introductory classes in plant pathology usually utilize the concept of the "disease triangle" to illustrate the importance and interrelationships of the three main components of plant disease: the host plant, the disease organism, and the environment. Furthermore, many plant diseases are abiotic in nature; that is, they are caused by environmental factors alone.

Environmental influences are particularly important with diseases in forest nurseries. Pathologists studying nursery diseases are aware of the importance of environmental factors because germinating seeds and young succulent seedlings are probably more sensitive to the environment than at any other time in their ontogeny. *Nursery diseases are particularly interesting and frustrating because we knowingly select, or create, the environment.*

The objective of this paper is to discuss a few of the ways in which the environment influences disease in tree seedling nurseries. We will first look at the nursery site selection process and some of the attempts to deal with less than optimum environments. Secondly, we will discuss the unique situation where the environment is consciously and deliberately created - the production of container seedlings in greenhouses.

SELECTING THE ENVIRONMENT

Nursery Site Selection

The selection of a nursery site is an obviously critical phase in the development of a tree seedling nursery. Experienced nursery managers can easily produce a list of biological factors that should be considered when analyzing a nursery site such as soil texture, water quality and growing climate. In actual practice, however, most nursery sites are not chosen solely on their potential for growing seedlings. The final choice in the selection of a nursery site is always a compromise between biological and managerial considerations.

The principal biological factors to consider when analyzing a potential nursery site are listed in Table 1. Soil texture is one of the most important site selection factors; a sandy loam texture is recommended not only for good seedling growth but also for rapid drainage and ease of lifting during seedling harvesting operations. Yet, in a recent survey of the major criteria used in the site selection of 15 nurseries in the northwestern U. S., only 20% of the nurserymen listed soil texture as the most important reason that their site was selected (Morby, In press).

Other non-biological factors must be evaluated during the site selection process (Table 1) and many times these managerial considerations receive high priority in the final selection. In the final analysis, political realities often outweigh biological necessities when tree nursery sites are selected.

Table 1 - Factors to Consider during Bareroot Nursery Site Selection

Biological Considerations

- Soil quality
- Water quality
- Climate
- Topography

Managerial Considerations

- Land availability and cost
- Labor supply
- Utility access and cost
- Transportation access
- Proximity to markets
- Political realities

The end result of this compromise between biological and managerial factors is that many tree nurseries are located on less-than-ideal sites and many nursery diseases can be directly attributed to problems with these sites. Examples of these problems are numerous but one classic example is the severity of damping-off in nurseries with heavy-textured or alkaline soils (Filer and Peterson, 1975). Environmental conditions can also predispose plants to Phytophthora root rot; adverse soil conditions such as waterlogging, high salinity or moisture stress have been shown to increase incidence of root disease (McDonald, 1982). Jack Sutherland (pers. comm.) of the Canadian Forest Service has observed that U.S. bareroot nurseries suffer more from soil-borne diseases like *Fusarium* and *Phytophthora* than comparable nurseries in British Columbia. He attributes this to the fact that more U.S. nurseries are "off-site" with heavier, poorly drained soils and concludes that environmental factors such as soil texture are given more weight in the site selection process in British Columbia.

Most nursery managers realize that their site has certain deficiencies and have developed specific cultural practices to overcome or at least modify these factors to acceptable levels.

Modifying a sub optimum site

Because soil is the basic resource in bareroot nurseries, many site-related problems can be traced to soil characteristics. One of the most graphic examples of a soil problem is a nutritional disease called lime-induced chlorosis which is found in many nurseries in the Interior West. This disease develops when acid-loving conifer seedlings are planted in alkaline or calcareous soils; the diseased seedlings appear yellow and stunted and usually do not make shippable grade. There is no quick cure for this ailment but the most promising treatments include applications of Sequestrene 138 which is a specially-chelated iron fertilizer, soil acidification and increasing organic matter levels. The Albuquerque tree nursery has been struggling with this problem for 7 years and has only recently begun to consistently produce normal seedlings.

Water quality is another critical factor in bareroot nurseries and, although there is no real corrective treatment for saline water, there are some management techniques that will minimize the problem (Landis, 1982). The best solution to marginal water quality is to avoid the problem completely by converting to a container nursery where the water can be injected with acid and a balanced array of nutrients. The Nevada Division of Forestry elected to build container nurseries at their two locations rather than attempt to deal with water and soil problems in a bareroot nursery situation.

A striking example of site modification can be seen at the Bessey Nursery in Nebraska. This nursery was established in the early 1900's in western Nebraska to provide tree seedlings for the afforestation of the surrounding Sand Hills. The soil and water were suitable for seedling production but the persistent wind caused problems in both summer and winter. This site problem was remedied by the establishment of windbreak plantings around all nursery blocks and recent attempts to expand nursery seedbeds into new areas without protective windbreaks has re-emphasized their importance.

Bedhouses are an extreme example of site modification in bareroot nurseries and are actually a kind of hybrid between bareroot and greenhouse nurseries. Bedhouses are portable structures that are placed over bareroot beds to extend the growing season so that a larger seedling can be produced in a shorter period of time. The principal benefit of these structures is that they protect the seedling from early season frosts and increase soil and air temperatures through passive solar heating. Some bedhouses even have supplemental heaters and automatic ventilation. The bedhouses at the Wind River Nursery at Carson, Washington have been quite successful and produce 900M 1+0 seedlings at a cost only 16% greater than standard 2+0 stock (Hansen, 1982).

CREATING THE ENVIRONMENT

Container nurseries - the ultimate site modification

The previous examples illustrate some of the practices that nursery managers use to modify sites that are less than ideal for growing bareroot seedlings. The ultimate step in modifying the environment is to produce seedlings in containers in the completely-regulated environment of a greenhouse.

The principal objective of a container nursery is to optimize all the environmental factors that limit tree seedling growth. The seedlings are sown at regular spacing in an artificial soil mix that is formulated for ideal pH and porosity. The growing environment is automated to maintain day and night temperature, relative humidity, carbon dioxide concentration and daylength at optimum levels for rapid growth. This procedure is quite successful because seedlings that take 3 years to produce under normal bareroot culture can be grown in one year as container seedlings.

Unfortunately, an environment conducive to rapid seedling growth is also ideal for many nursery pests. The greenhouse environment generates a high disease potential for several reasons:

1. Favorable climate - Greenhouse temperatures are warm with little diurnal or seasonal variation and relative humidities are seldom lower than 60%. Wind velocities are minimal even when the cooling fans are operating (Hussey et al., 1969). These ideal conditions are also favorable for rapid development of many pest species.

2. Very dense stocking levels - The ideal growing density for most bareroot seedlings is approximately 25 per sq. ft.; this stocking level is critical for proper seedling growth and development, especially for stem caliper. Many types of containers, and particularly smaller ones with capacities of 2-4 cubic inches, are designed to produce seedling densities of up to 100 per sq. ft. These dense stocking levels are economically attractive but generate seedlings with large tops with little lignification and crowding promotes premature needle senescence on the lower stem. This abundance of dead tissue and the close proximity of individuals can lead to outbreaks of opportunistic pathogens such as Botrytis.

3. Monoculture - In an ecological sense, greenhouse environments are unique because of the genetically uniform crops that are normally grown (Hanan et al, 1979). In container nurseries, the entire crop usually consists of a few closely related species and seedling orders are composed of seedlings from the same seed source. To aggravate the situation, all the seedlings are sown at the same time and therefore are always at the same stage of growth. This extreme monoculture provides a very uniform food base for the rapid build-up of plant diseases.

4. Accelerated growth promotes succulence - Seedlings grow very rapidly in the greenhouse environment and shoot growth can reach several times the normal rate. This rapid growth consists of large, thin-walled cells that are very succulent and therefore susceptible to attack by diseases and insects.

5. Sterile environment - The completely controlled environment in the greenhouse is geared towards pest exclusion. The greenhouse structure, benches, and containers are normally sterilized between crops and the potting soil is also treated to eliminate any potential pests. These sterile conditions, however, can lead to outbreaks of normally innocuous organisms because natural predators or competitors are also eliminated. As a result, whiteflies and other insects that reproduce rapidly can reach epidemic proportions in a very short time. Fungus gnats are normally saprophytic but one species (*Bradysia paupera*) has become parasitic on seedlings and cuttings in forestry greenhouses in Utah and Colorado.

Problems with accelerated growth

Accelerated growth produces large seedlings in a short time period but these container seedlings are susceptible to a variety of physiological and morphological problems that are not common with bareroot stock.

Non-dormant stock - The rapid seedling growth that reduces rotation times can also lead to problems after the seedling leaves the nursery. Often, container trees are not hardened sufficiently and become damaged during shipping. This is particularly true with seedlings that have broken bud because the new leader is very fragile and may be broken off during handling or abort later on the outplanting site. Seedlings that are not cold-hardy can also be damaged by frost when they are transported to higher elevation planting sites. Non-dormant seedlings are also more likely to suffer physiological stresses on severe outplanting sites.

Container seedlings are produced in an artifical environment and are therefore out of phase with natural cycles. If they are not allowed to acclimatize in a shadehouse for a sufficient amount of time, they may become "physiologically confused" after outplanting. Seedlings that do not become dormant in the shadehouse typically exhibit poor root regeneration after planting which may reduce subsequent height growth or even cause mortality. This mortality may not be evident during the first outplanting season because the root plug can provide enough moisture to keep the seedling alive. When pine container seedlings that had begun shoot expansion were outplanted in southwestern Colorado, they showed good initial survival and growth but suffered significant mortality the following year.

Root:shoot ratios - Due to the rapid shoot growth in the greenhouse environment, it is difficult to maintain a good morphological balance between shoot, caliper and root growth. Typically, seedlings grown under high nitrogen fertilization and long photoperiods produce shoot growth at the expense of root and diameter growth. This growth habit results in container seedlings with poor shoot: root ratios which may be stressed after outplanting because the large shoot transpires moisture faster than the smaller root system can absorb it. Many of these "top-heavy" seedlings do not remain upright after planting which subjects them to a variety of environmental stresses.

In the final analysis, the accelerated growth of container seedlings that is responsible for shorter rotations in the nursery may prove detrimental on the outplanting site. Container seedlings should be grown so that they are morphologically well-balanced and scheduled for a mandatory hardening period to allow them to acclimatize to the natural environment. Top-heavy seedlings that are not dormant or cold-hardy are bound to be stressed after outplanting and it is well established that stressed seedlings are more susceptible to biotic and abiotic diseases.

CONCLUSIONS AND RECOMMENDATIONS

1. Tree seedlings are particularly sensitive to environmental factors and many nursery problems can be directly or indirectly traced to the nursery environment.

2. Because of the importance of environmental factors in nursery pathology, biological factors should be given additional emphasis during nursery site selection.

3. If a suitable nursery site cannot be located, then a container seedling nursery should be considered.

4. Growing schedules for container seedlings should be designed so that seedlings are morphologically well-balanced, dormant and cold hardy before shipment to the field.

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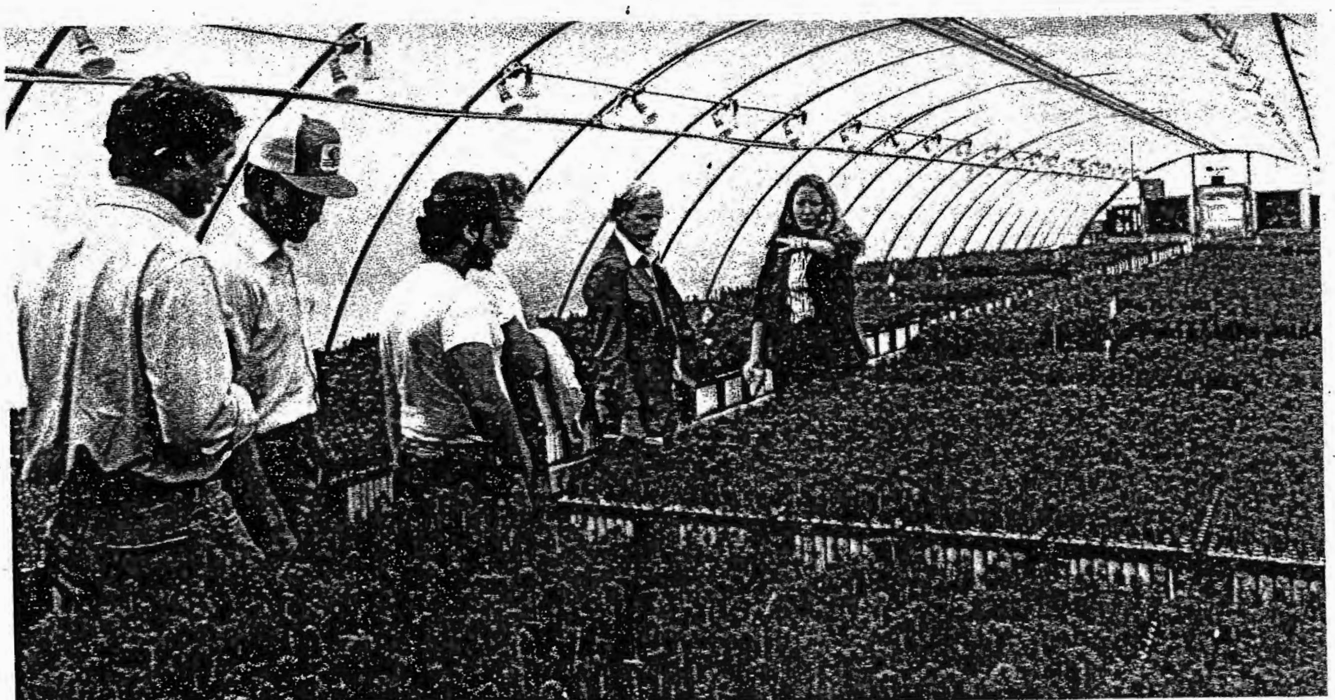
Coeur d'Alene Nursery Tour

A tour of the USDA Forest Service Nursery at Coeur d'Alene was conducted by Pat Malone, Joe Myers, and Cleve Chatterton following the nursery disease panel on Wednesday afternoon. The tour emphasized production procedures, including seed extraction, sowing, seedling production in bareroot beds and containers, lifting, sorting, and storage. Problems, including insects and diseases, were discussed as well as practices used to reduce losses. Several diseases including Botrytis blight, Fusarium root disease, Meria needle cast, and western gall rust were seen. Discussions centered on how to identify these diseases, their general impact, and procedures used for control



PROGRAMMABLE HANDHELD CALCULATORS AS AN AID TO MAKING FOREST DISEASE MANAGEMENT DECISIONS

Robert D. Harvey, Jr., Craig L. Schmitt, and Gregory M. Filip

WHITE PINE BLISTER RUST - ROBERT D. HARVEY, JR.

Good afternoon. Thank you for providing me with the opportunity to discuss my use of the handheld programmable calculator as an aid to making forest disease management decisions. The equipment that I will be referring to today is the Hewlett-Packard 41CV calculator with a card reader and printer. For those of you unfamiliar with this type of system, the calculator will retain a program even after being turned off, and the card reader is a device that allows the operator to record programs on magnetic strips for saving and reentry into the calculator in the event the original program has been removed. A card reader is not absolutely necessary for using the calculator, but it will prove invaluable if many different people use the calculator or if it is subject to frequent memory purging. Those of you who have ever had to enter a 300-400 line program and then debug it to remove your input errors only to have someone erase it the next day will know what I am talking about. The printer also is not absolutely necessary; however, it can save hours or even days in debugging a program by allowing the operator to trace the sequence of calculations or branching step-by-step. Beyond this, it provides a hard copy of program results for easy future reference. The basic calculator can be purchased for about $200 and, with the card reader and printer, for $600 to $800 depending on source.

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I use the system not only for processing data in the office and field, but also for hands-on experience for land managers during training sessions. The HP 41CV's are commonly used by many USFS Districts for other uses so they are readily available.

The program I will be referring to today and with which I have presented many training sessions, includes a group of programs developed by Dr. Geral McDonald of the Intermountain Forest and Range Experiment Station. It is called the White Pine Blister Rust Risk Index and Status System and, among other things, is used to determine the hazard to western white pines, in a specific area, from white pine blister rust. The advent of the computer made the development of this program possible, and this system has made it operational in the field.

Data necessary to run the program are age, height, and number of cankers per sample tree. These are not only easy to gather, but also easy to input in the field.

The program can be used to grow a tree or stand for a specified period of time or to a defined diameter limit. If grown to a diameter limit, the current diameter also must be input. The outputs of this program used in determining hazard include a rust index or number of cankers we would expect the average tree to get per year; a distribution index or deviation of canker distribution from normal or random; a proportion of the stand the investigators can expect to become infected in a specified time period; and a proportion of the stand they can expect to lose to mortality in that same time period.

The advantage of this system is that all prompting for inputs and all outputs are identified by words or abbreviations. This eliminates the need to remember what is entered where, or what a particular output means. Data can be collected, summarized, and entered right in the field.

The program can be used not only for hazard rating an area so the proper amount of disease resistance in planting stock can be balanced with the risk, but also to aid in making management decisions on the current stand. If a stand is badly infected at an early age, the program may lead to a decision to interplant by showing an unacceptable loss over the time period specified. On the other hand, lesser levels of infection may lead the land managers to run the program to determine loss at a minimum harvest diameter. They may then choose to run the program to an optimum harvest diameter to see how much additional loss can be expected. Based on these findings, the stand rotation schedule may be shortened or lengthened. Since these different scenarios may be examined in the field, land managers have the opportunity to actually observe the stand while deciding on a course of action. Included in the scenarios that can be examined are those that estimate time to death of a tree from branch or stem cankers. These also can be run on the spot with a minimum of additional data and little time expenditure.

LODGEPOLE PINE DWARF MISTLETOE - CRAIG L. SCHMITT

INTRODUCTION

I would like to present several uses for programmable handheld calculators in "on the ground" decisionmaking using a yield model we have recently developed. This model, along with our economic analysis, has been assembled into the program LPDMVOL, designed for the Hewlett-Packard 41CV. This program can be used to estimate potential, current and future yield of dwarf mistletoe-infected lodgepole pine and schedule harvests to maximize economic return.

Stand data required to run LPDMVOL are all present from the standard Region 6 Stand Exam Summary Tables. Additional information is only needed when a more precise estimate of site index is required.

Specifically, the Program:

1. Estimates site index - using either of two slightly different approaches.

2. Estimates potential (if healthy) cubic foot volume per acre at any age, based on Dahms' (1975)[1/] equations.

3. Estimates current and projected diseased stand volume based on equations derived from 42 fixed-area plots established in central Oregon.

4. Estimates the impact of dwarf mistletoe on yield by expressing estimated volume as a percentage of potential volume.

5. Does a Present Net Value analysis on an immediate versus future clear-cut harvest.

SUBPROGRAMS

Four subprograms are included in LPDMVOL, each of which may be called up to do specific tasks.

Site Index

Site index can be calculated either of two ways. One, SIBC, uses information from the individual tree record in stand exam summary tables. The other, SIST, uses data from one or more trees specifically measured for site index.

SIBC - Site Index Base 100

1. data required

   - age at breast height
   - total height
   - trees per acre $\geq$1" DBH
   - basal area for trees $\geq$1" DBH

1/ Dahms, W.G.
1975. Gross yield of central Oregon lodgepole pine. In Management of Lodgepole Pine Ecosystems. 208-232 P. Edited by David M. Baumgartner. WSU, Pullman WN.

2. outputs

- quadratic mean stand diameter
- crown competition factor
- observed site index
- site index adjusted for stand density when CCF >125

3. example

Display	Description	Input	Output
AGE?	age at breast height	67	
HT?	total height	52	
TREES?	trees/acre ≥1" DBH	745	
BA?	basal area (ft.^{2}) for trees	103.5	
DABA	= quadratic mean stand diameter		5.087
CCF	= crown competition factor		143.2
SJ OB	= observed site index		63.0
SI ADJ	= adjusted site index		63.9

SIST - Site Index Sample Tree

1. data required

- basal area factor
- "in trees" including sample tree
- mean diameter (closest inch) of "in trees"
- height of sample tree
- age at breast height

2. outputs

- crown competition factor
- site index observed
- site index adjusted

3. example

Display	Description	Input	Output
BAF?	basal area factor	20	
IN TREES?	number of tallied trees	6	
AVE D?	mean DBH of tallied trees	6	
HT?	total height of sample tree	52	
AGE?	age at breast height of sample tree	67	
CCF	= crown competition factor		147.5
SI OB	= observed site index		63.0
SI ADJ	= adjusted site index		64.2

VOL IMPACT - Volume Impact

The VOL IMPACT subprogram estimates the current and future impact on yield by dwarf mistletoe.

1. data required

- dwarf mistletoe rating for stand
- mean dominant age of stand
- site index
- trees per acre ≥1" DBH
- quadratic mean stand diameter (from SIBC)

2. outputs

- impact due to mistoetoe; expressed as the ratio of estimated to potential (if healthy) volume
- crown competition factor (projected)
- potential cubic foot volume per acre (projected)
- estimated cubic foot volume per acre (projected)

3. example

Display	Description	Input	Output
YRS TO HARV?	time of projection	0	
DMR?	dwarf mistletoe rating	3.42	
DMR-P			3.42
AGE?	stand age at breast height	67	
SITE?	site index	63.9	
TREES?	trees per acre ≥1" DBH	745	
DABA?	quadratic mean stand diameter	5.05	
A/P RATIO =	mistletoe correction ratio		0.83
CCF-P =	crown competition factor		143.3
DAHMCF=	estimated cubic foot volume per acre if healthy		2164
DMCF =	estimated cubic foot volume per acre		1792

ECO IMPACT - Economic Impact

The ECO IMPACT subprogram is an extention of VOL IMPACT, estimating future yield and impact due to dwarf mistletoe. In addition, a present net value analysis is done on scheduling clearcut harvests.

1. data required

- time of projection
- length of future rotations
- current volume
- discount rate
- annual price appreciation rate
- current and estimated future costs and stumpage values
- stand parameters as in VOL IMPACT

2. outputs

- impact due to mistletoe; expressed as the ratio of estimated to potential (if healthy) volume
- crown competition factor (projected)
- potential cubic foot volume per acre for current rotation
- estimated cubic foot volume per acre (projected)
- potential cubic foot volume for future rotations (projected)
- present net value for current management plan, an immediate harvest, and the difference between the two

3. example

Display	Description	Input	Output
YRS TO HARV?	planned years to harvest	25	
ROTATION?	planned length of future rotations	80	
CURRENT CF?	current cubic foot volume	1792	
% DISC RATE	% discount rate	4	
% PRICE	% annual price appreciation rate	2.5	
F HARVEST	current and future costs and stumpage data		
MCF $, PREP $	$ per MCF; $ per acre		
CURRENT?	current	160↑, 150	
END ROTAT?	at the end of projection	250↑, 150	
NEW ROTAT?	for new rotations	250↑, 150	
DMR?	current dwarf mistletoe rating	3.42	
DMR-P	projected dwarf mistletoe rating		4.47
AGE?	current age	67	
SITE?	site index	63.9	
TREES?	current trees per acre	745	
DABA	quadratic mean stand diameter	5.05	
A/P RATIO =	mistletoe correction ratio		0.66
CCF-P =	projected crown competition factor		141.1
DAHMCF =	projected potential cubic foot volume per acre for <u>current</u> rotation		2908
DMCF =	projected current infected cubic foot volume per acre		1923
DAHMCF =	projected potential cubic foot volume per acre for <u>future</u> rotations		2537
DM$ =	present net value for current management plan (per acre)		383.36
CC$ =	present net value if we harvest immediately (per acre)		357.11
CC - DM$ =	value lost by continuing of the current plan (per acre); a negative value indicates a gain		-26.25

HEARTROT IN GRAND AND WHITE FIR - GREGORY M. FILIP

I. INTRODUCTION

I would like to present a program recently developed by myself in conjunction with Paul E. Aho, Pacific Northwest Forest and Range Experiment Station. The program was designed to be used on a handheld programmable calculator such as the HP 41CV.

We developed two equations to estimate the percentage of infection (by Indian paint fungus) and heartrot (by all decay fungi) in advanced white and grand fir regeneration in Oregon and Washington. The first equation estimates the percentage of potential crop trees with both dormant and active trunk infection of Indian paint fungus (*Echinodontium tinctorium*):

$$LOG_N\ (ET\%) = 1.1832\ (OVER) - 0.0632\ (LCR) + 6.3909$$

WHERE OVER = primary overstory species (0 or 1)
LCR = mean stand live crown ratio
LOG_N = natural logarithm
(R^2 = 0.42, SE = 0.98)

The second equation estimates the percentage of crop tree volume (ft^2) with both incipient and advanced decay caused by all decay fungi including primarily *E. tinctorium*, *Fomes annosus*, *Pholiota limonella*, *Hericium abietis*, and *Haematostereum sanguinolentum*:

$$LOG_N\ (DEC\ VOL\%) = 1.8219\ LOG_N\ (AGE) + 0.8386\ LOG_N (WND\%) - 0.4151\ (ASP) - 10.4222$$

Where AGE = Mean stand total age
WND% = Percent of trees with one or more wounds or conks
ASP = Stand Aspect (0 or 1)
LOG_N = natural logarithm
(R^2 = 0.70, SE = 0.79)

II. STAND SAMPLING

Depending on stand shape, an examiner should follow one or more parallel transects through the stand and select one potential crop tree (based on height, form, live crown ratio, and wounding) nearest a sample point located every two or three chains along the transect. The idea is to systematically obtain at least 20 sample trees per stand. If previous stand exam data is available, this may be used, but additional information may need to be collected. Large stands with a wide range in aspect or wounding frequency should be stratified into homogeneous units, and each unit sampled separately.

III. DATA COLLECTION

A. Stand Data

1. Primary Overstory Species (OVER) - The examiner should determine if the overstory is (or was) dominated by pine (ponderosa or lodgepole) or fir (true fir or Douglas-fir). If 60% or more of the volume or basal area is pine, enter "0". If 40% or more is fir, enter "1". If the overstory is no longer present, (1) examine stumps to determine overstory species or (2) use plant community classification to determine overstory species. Code for fir for true fir, hemlock, or mixed-conifer types. Code for pine for lodgepole or ponderosa-dominated forest types.

2. Aspect (ASP) - Record the aspect of the stand. Enter "0" for northerly aspects (N, NW, NE, OR W) or "1" for southerly aspects (S, SE, SW, E).

B. Individual Tree Data

1. Percent of Trees Wounded or with Conks (% WND) - Record if crop tree has one or more wounds (>1 in.^{2}) or trunk conks (any species). Include top breaks, dead tops, frost cracks, fire scars, and wounds on major exposed roots. Sum the number of trees with one or more wounds or conks and divide by

the number of sample trees in the stand to obtain the percent of trees with wounds or conks. Method is limited to stands greater than 15% but less than 90% of the trees wounded or with conks. Also, if most wounds are recent (less than 10 years old), actual current decay volumes may be less than estimated. If average size of wounds for the stand exceeds 2 ft.^{2}, actual current decay volumes may be higher than estimated.

2. Mean Stand Live Crown Ratio (LCR) - Obtain live crown ratio (nearest 5%) for each crop tree. Divide length of live crown (as measured from top of tree to last major live branch where it joins the stem) by total tree height. Sum the individual live crown ratios and divide by the number of samples to obtain mean stand live crown ratio. Method is limited to stands with mean LCR's greater than 60% but less than 85%.

3. Mean Stand Age (AGE) - Obtain the total age for each crop tree by increment boring at breast height and adding the appropriate number of years to give total age. Sum the individual ages and divide by the number of samples to obtain mean stand age. Method is limited to stands more than 40 years but less than 260 years old.

4. Optional - Mean Stand DBH and Mean Current Radial Increment - Measure DBH and last 10-year radial growth for each crop tree and average for the stand. Although DBH and current increment are not needed to estimate percentage of infection or decay, they may be useful when determining years for additional diameter growth to reach merchantability.

IV. OTHER LIMITATIONS

Besides the limitations already expressed for each variable, other restrictions on the use of the sampling method should be mentioned. The method was developed for stands of advanced regeneration east of the Cascade Mountains in Oregon and Washington, especially in the Blue Mountains. If the method is used in white or grand fir stands west of the Cascade Mountains, in California white fir stands, or in grand fir stands in British Columbia or Idaho, values obtained may not be valid since the method was not developed in these areas. Likewise, the method was not tested for other coniferous species that serve as hosts for the Indian paint fungus, such as noble fir, Pacific silver fir, subalpine fir, Shasta red fir, western hemlock, and mountain hemlock. By using the procedures outlined in the final guide (to be published later), it may be possible to test existing equations or develop new equations for other species and areas not tested in this guide.

V. ESTIMATING THE FUTURE PERCENTAGE OF DECAY

Not only can the two equations be used to estimate the current incidence of infection and decay, the equation used to estimate decay can be used to predict percentage of decay (both cubic and board feet) at any point in the future, since "mean stand age" is a variable in the equation. Also, the variable "percent of trees with wounds or conks" can be increased, especially if future stand entries will be made. This variable should be increased about 1% every decade to account for the increase in naturally-caused wounds. Board foot (Scribner) decay percentages can be calculated for stands 11 in. DBH and greater by multiplying cubic foot percentages by 2.7. Board foot decay percentages are always higher than cubic foot percentages because of scaling differences between cubic and board foot measures. Also, board foot decay percentages also include deductions for shake, frost cracks, and sound volume lost in cull logs.

VI. INTERPRETING THE RESULTS

The decision to retain or destroy stands of advanced white or grand fir regeneration and the management of stands to be retained should be influenced by infection and decay.

estimates. Potential crop trees with low infection levels (<20%) and low decay percentages (<2% ft.^{3} at 100 years) generally have a relatively low incidence (<25%) of wounding and good live crown ratios (>50% under pine overstories or >75% under fir overstories). Provided that root disease centers are not present, such stands can be managed for extended rotations (150 to 200 years) with no special precautions provided that substantial injury does not occur and reasonable increment is maintained. Decay estimates should be recalculated if substantial amounts of wounding occur either naturally or following stand entries.

Potential crop trees with low infection levels (<20%) but high decay percentages (>2% ft.^{3} at 100 years) have a high incidence of wounding (>25%) and good live crown ratio (>50% under pine overstories or >75% under fir overstories). Such stands should not be managed for extended rotations but can be managed on rotations less than 150 years provided that special precautions are taken. Stands should be precommercially thinned early with stringent restrictions against crop tree wounding. Most decay columns that may result from thinning wounds on small trees will be relatively small - no larger than the diameter of the tree at the time of wounding. Wounding resulting from stand entries should be prevented unless stands will be harvested within 10 years. Wounds created within 10 years will not have sufficient time to develop decay. Decay estimates should be made after each entry if additional wounding occurs. Stands should be harvested when projected decay levels become unacceptable.

Potential crop trees with high infection levels (>20%) and low decay percentages (<2% ft.^{3} at 100 years) generally have a low incidence (<25%) of wounding but poor live crown ratios (<50% under pine overstories or <75% under fir overstories). Such stands should be managed similarly to stands with low infection but high decay percentages provided that crop tree live crown ratio >50 percent and leader growth is good (8 in./year) to insure release.

Potential crop trees with high infection levels (>20%) and high decay percentages (>2% ft.^{3} at 100 years) have a high incidence (>25%) of wounding and poor live crown ratios (<50% under pine overstories or <75% under fir overstories). Such stands should be replaced immediately or the fir component destroyed unless projected percentages of decay are acceptable.

As a wrap-up, these systems are not only invaluable as aids in training sessions, but also can show the land managers that, with a minimum of extra effort, they can get considerable information on stand potential that is extremely useful for making forest disease management decisions.

ELECTRONIC DATA LOGGERS IN FORESTRY RESEARCH

Robert F. Scharpf

ABSTRACT

Electronic data loggers can facilitate the collection in the field and processing of research data to be analyzed by computer. Transcription of data to computer code sheets, manual data entry, and data verification are virtually eliminated. Care in handling, and training in the use and maintenance of data loggers are essential, however. Small data sets are still more efficiently taken by hand.

INTRODUCTION

The collection and analysis of field data is a time consuming and expensive part of forestry research. Calculators and computers have speeded up much of the data processing and analysis, but even now much of the data is still collected and processed by hand. This process usually involves recording data on field sheets, transcribing data onto computer coded forms in some cases, and entering data into a computer file either by keypunching and verifying of cards or by using a computer terminal. Electronic data loggers, which are now available, allow collection and transmission of data directly into a computer without manual processing.

This paper describes electronic data loggers, their use, and associated advantages and disadvantages.

WHAT ARE DATA LOGGERS?

In general, data loggers are much like hand calculators: small, battery operated, electronic devices that record, store, and transmit data to a computer. Some have solid state components (memory chips), whereas others take a cassette tape. Some accept data entered by hand only, some record data automatically (e.g., temperature recording devices), and some are designed for both. Data recorders come preprogrammed at the factory in some cases, or can be programmed to take the type of data required. Some only log and transmit data, and others also do simple calculations (like sums and means). Because their main function is storing and facilitating the entry of data into a computer, data loggers are not practical for collecting data that will not be analyzed by computer.

WHAT ARE ADVANTAGES OF USING DATA LOGGERS?

Data loggers are compact, portable, and, in general, no more cumbersome to use than an ordinary clipboard and data sheets. Some models can be used with a belt and neck band, leaving the hands free to take field measurements.

Many data loggers have large storage capacities equal to hundreds of field data sheets.

They reduce errors in data in that keypunching, verification, and other manual data handling are eliminated.

Collected data can be edited and analyzed more quickly and economically because data processing time is reduced or eliminated.

WHAT ARE DISADVANTAGES OF USING DATA LOGGERS?

Because data loggers are sophisticated electronic devices, they are fairly delicate and subject to breakage and repair. Reasonable care must be exercised in their use. If they are broken, damaged, or lose power, any data collected could be lost.

Data loggers can be properly operated or maintained only by individuals who have received special training.

They are expensive (at present $1,000-$4,000).

They are inflexible, that is, they take only the data they are programmed to take. One cannot change the data collection procedure readily or take additional "notes" or data without reprogramming.

They do not display the data in the field like a data sheet does. Separate procedures must be used to view the data after they are entered. Only after the data are transferred to the computer and printed out can one view the data en masse. For small data sets, recording data on field sheets may be preferable.

WHAT ARE THE PROCEDURES FOR USING DATA LOGGERS?

The first step in using data loggers is learning how to program them. In many ways data loggers are nothing more than small computers: they must be told what to do (programmed), and then they follow the instructions in a given sequence. Much thought and care should be given to the programming process so that the data can be collected as efficiently and correctly as possible. Like computers, different data loggers vary in ease of programming. In addition to learning how a logger is programmed, one should become familiar with maintenance and limitations of the equipment (e.g., battery charging or replacement, memory storage limitations). Also, steps in editing incorrect data and other troubleshooting procedures for correcting errors or changing programs should be worked out before attempting to collect field data.

The next step, entering data, is usually simple and straightforward, but it must be done in a consistent sequence, and every digit and decimal point must be included. If no data exist for a given item, "0" or "no data" must be entered so that the logger can proceed to the next entry. Errors should be corrected at the moment of entry. The final procedure in the data collection process is transferring stored data to a computer. This is achieved in one of several ways: "dumping" directly from the logger into the computer; transferring to cassette tape and then to a computer; or transmitting by phone with a modem, miniterminal, or similar device. The most foolproof method of data transfer I have used is the "direct dump" method. As a precaution, I recommend making "backup" tapes before dumping and clearing data from the memory. Phone transmission is usually successful but unreliable from some locations. Whichever transfer method is used, one should verify that the data have been accepted and are on file in the computer. At this point, the data in the logger can be cleared or the program changed for additional data collection.

WHAT IS THE OUTLOOK FOR DATA LOGGERS?

The Pacific Southwest Forest and Range Experiment Station has recently purchased several data loggers. To date they have been successfully used to collect field data on dwarf mistletoe permanent plots, data on the growth of seedlings in nursery beds, and temperature and light transmission data from snow packs. Even broader use of data loggers is anticipated now that they have been tested. We are in an electronic revoluation and there is little doubt that computers and computer-related devices are here to stay. Data loggers are only one of the many new computer accessories that can make our work easier and more efficient. Where applicable, they are very powerful tools that we, as scientists, should learn how to use to the best advantage. They are not a panacea to all data collection, however. We need to determine when and how these new tools can best be used.

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LAMINATED ROOT ROT

by

Larry Weir

The Oregon State Department of Forestry has funded a slide-tape program dealing with laminated root rot. We have been showing the program to state forestry personnel in training sessions and have requested feedback that would help us improve the program. This need for feedback is why we have asked to present it here. This will probably be the last exposure before we incorporate all valid suggestions in a final revision.

Unfortunately, in the preparation of a slide-tape program such as this one is limited by the size of the slide tray and we felt that the use of more than one tray would result in a loss of continuity and attention. So before we show the program we can acknowledge the fact that in the eyes of those who know the root rot well there may be some omissions. These are inevitable when numbers of slides must be curtailed.

However here is the program and if you feel that it can be improved in any way please make note of your comments and hand them to me sometime before Friday noon.

ENVIRONMENTAL FACTORS INFLUENCING THE RATE OF SPREAD OF PHELLINIUS WEIRII

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INTRODUCTION

Phellinus (Poria) weirii (Murr.) Gilb. (laminated root rot) infects all commercially important coniferous species in the northwestern United States and British Columbia. The fungus primarily spreads from tree to tree by ectotrophic mycelial growth across root contacts. New infections in a stand arise when the developing roots of young trees contact residual infested stumps from the preceding stand (Wallis and Reynolds, 1965). P. weirii has been found to survive saprophytically on old stumps for 50 years or more (Childs, 1963; Hansen, 1979). Factors affecting survival of the fungus on old infected stumps, therefore, will have much influence on root rot damage in the next generation. Identification of these factors is the focus of considerable ongoing research aimed at reducing losses to laminated root rot (i.e., Hansen, 1979; Nelson et al., 1978; Nelson, 1967; Thies and Nelson, 1982; Thies and Russell, 1983; Rose et al., 1980).

Another major factor governing the extent of root rot spread in a Douglas-fir stand is the rate of ectotrophic growth along an infected root. The rate of expansion of infection centers averages 0.2 to 0.3 m/yr (Nelson and Hartman, 1975; Childs, 1970), but many centers remain quiescent for years while others appear to increase rapidly. Rate of ectotrophic extension along individual inoculated roots has also been measured, but apart from scattered observations, the variables controlling this extension have not been determined. Presumably, the same factors that affect fungal survival could also affect the rate of ectotrophic growth. This paper reports on a study where we attempted to determine the relationships between the following environmental factors: soil moisture, temperature, nitrogen; ph, compaction, and microorganisms to the rate of ectotrophic growth of P. weirii along Douglas-fir roots.

MATERIALS AND METHODS

Rate of ectotrophic growth of P. weirii was measured in the laboratory by inoculating either 22 cm long, 1.5 cm diameter Douglas-fir branch sections, glass rods or wood dowels, buried in 475 cm^3 soil tubes. The extent of mycelial growth was measured after 25 days. Inoculum consisted of autoclaved Alnus rubra stem sections, incubated 8 weeks and then placed adjacent to the end of each substrate. 25 soil tubes were constructed for each substrate type. Similar tests were performed using only Douglas-fir branches to compare growth along pasteurized, autoclaved and forest soils.

The effect of soil moisture on ectotrophic growth of P. weirii was tested by inoculating 22 cm branch sections of Douglas-fir. Soil surrounding each treatment was air-dried and then water added to obtain 2.7, 5, 10, 15, 20, 25 and 35% moisture content (wet weight basis). Twenty branch sections were inoculated for each moisture level.

Field tests were conducted in a 20 year old Douglas-fir plantation near Corvallis, Oregon. Roots were inoculated by tying Alnus inoculum blocks to living roots. Fifteen roots were inoculated for each treatment within each environmental factor compared. Test treatments were obtained by altering the soil around inoculated roots. One year later, ectotrophic mycelial growth was measured to determine treatment differences. Three soil moisture treatments were compared. Treatment 1 was watered weekly to field capacity during the late spring and summer months. Roots in the second treatment were covered with tents to shed rainfall during the rainy (winter) season. Treatment 3 was exposed to natural conditions (control). Three treatments were also installed to investigate effects of pH. Approximately 0.3 m^3 of soil was removed from around each root and replaced with forest soil that had been amended with sulfuric acid (soil pH 4.5), lime (pH 6.4), or no amendment (pH 5.5). Effects due to difference in microorganisms were similarly tested by replacing the area around roots with pasteurized forest soil and unpasteurized (unamended) forest soil. Temperature was tested by comparing treatments installed on a south slope. Roots on the uphill (cool) and downhill (warm, exposed) sides of 15 trees were inoculated. Soil temperatures were monitored through the year. A compaction treatment was applied after inoculation by a vibrational plate road grader. Compacted soil measured 1.19 g/cm^3 compared to 0.94 g/cm^3 for control inoculations. Three nitrogen levels were established by spreading urea, glucose or nothing in a 10 foot radius around the bole of each inoculated tree and watering thoroughly. Urea was applied at a rate of 600 lbs/acre N and glucose was applied at 400 lbs/acre. An additional application of 2130 lbs/acre glucose was added three months after the initial treatment. Soil tests 3, 7 and 10 months after initial setup confirmed differences were maintained between treatments.

RESULTS AND DISCUSSION

Ectotrophic growth averaged 14 cm after 25 days on branch sections placed in soil tubes. Growth on wood dowels was sporadic and no growth was observed on glass rods. Rate of growth was similar in autoclaved, pasteurized and forest soils, but growth in the soil was profuse only in the autoclaved and pasteurized treatments. Apparently in the soil tube situation, competition by microorganisms limits growth of P. weirii to the area immediately adjacent to the Douglas-fir branch but does not markedly affect the rate of ectotrophic growth. The soil moisture test supports this conclusion. Ectotrophic growth of P. weirii was greatest at the 15% level, a level not limiting growth of the fungus, but low enough to prevent high competition.

The results of the field studies are shown in Table 1. Soil pH did not affect inoculation success, but significant differences (P = .10) in the extent of mycelial growth between the control and the two amended treatments were found. These findings agree with previously published findings of a pH optimum of 6.0 for in vitro growth of P. weirii (Li et al., 1967). Soil compaction had little effect on either establishment or extent of mycelial growth of P. weirii. Soil pasteurizaton caused a large change in inoculation success (pasteurized soil, 47% establishment vs 87% establishment for "wild" soil), but did not produce any significant difference in the extent of mycelial growth (13.4 vs 14.3 cm). The large difference in inoculation success was unexpected; perhaps the pasteurized soil was quickly colonized by soil antagonists. In contrast, the observed lack of difference in the extent of mycelial growth is similar to the results found in the laboratory. Temperature caused large differences in inoculation success but not much change in extent of ectotrophic mycelial growth. The lack of inoculation success in the warm treatment was probably due to the large temperature extremes (up to 24°C) encountered during the warm summer months. Failure to obtain a difference in the extent of ectotrophic mycelial growth may be attributed to the fact that the average difference between the two treatments during the summer months was only about 3-1/2 to 4°C. Notice, however, that ectotrophic growth was greater for the temperature treatments than for all others (Table 1). These treatments were established alone on an open south slope and soil temperatures, each in the cool treatment were warmer than for the other studies. Thus, it appears that temperature does influence the rate of ectotrophic mycelial growth. Soil moisture and nitrogen had similar effects on the extent of

Table 1. Effect of soil environment on growth of *Phellinus weirii* along inoculated Douglas-fir roots.

	Inoculation Success		
Treatment	Establishment (%)	Growth beyond inoculum (%)	Extent of growth (cm)
Moisture			
wet	60	47	11.7
dry	71	64	14.2
ambient	71	64	17.9
Temperature			
cool	93	87	22.5
warm	40	40	23.3
pH			
acidic	61	40	9.4
basic	50	20	8.1
ambient	46	40	14.0
Nitrogen			
elevated	20	13	10.6
reduced	47	33	13.4
ambient	71	64	17.9
Compaction			
compacted	57	50	17.3
ambient	64	57	19.4
Microorganisms			
pasteurized	47	33	13.4
ambient	87	73	14.3

ectotrophic growth of *P. weirii*. Changes in both nitrogen or water, either up or down, reduced mycelial growth. This reduction is statistically significant in all cases (P = .10), except between the field and dry treatments. Failure of the tarps to completely keep moisture out of the dry treatment probably accounts for the lack of significant differences. However, a trend towards reduced ectotrophic growth in the dry treatment is evident. In contrast, soil moisture had little effect on establishment of *P. weirii*, while both urea and glucose treatments had a marked effect. In particular, the addition of urea had an extremely large effect on establishment (20 and 71% for urea treated and field soil, respectively). This lack of survival of *Phellinus weirii* in soils with high nitrogen levels has been observed before (Nelson, 1970). The reduction in establishment and ectotrophic growth with urea additions is probably due to either direct inhibition of *P. weirii* by the nitrogen fertilizer, antagnoism by increased populations of microorganisms or inhibition due to increased host vigor. Likewise, reduced establishment and ectotrophic mycelial growth after glucose treatment may be due to the direct effects of decreased nitrogen availability for *P. weirii*, or indirect inhibition due to increased numbers of microorganisms.

Although high variation in ectotrophic growth with treatments limited the number of statistically significant differences obtained by this study, many notable trends are evident. Soil pH, temperature, moisture, microorganisms and nitrogen all appear to influence establishment and ectotrophic mycelial growth of *P. weirii*. Soil environment thus seems to have an integral part in dictating the rate of spread of *P. weirii*.

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FUNGICIDE TRIALS FOR CONTROL OF PHOMA AND SIROCOCCUS AT THE HUMBOLDT NURSERY

John Kliejunas

ABSTRACT

Ten fungicides to control Phoma blight of red fir and five fungicides to control Sirococcus tip blight of Jeffrey pine were evaluated at the Humboldt Nursery. Fungicides were applied at approximately one month intervals from September, 1982 to May (red fir) or June (Jeffrey pine) of 1983. Efficacy was determined by comparing the percentage of red fir killed or Jeffrey pine cankered in each treated plot with adjacent untreated plots. None of the fungicides tested effectively controlled Phoma blight of red fir. Three fungicides--clorothalonil, ectaconazole, and triadimefon -- were efficacious in controlling Sirococcus tip blight of Jeffrey pine; vinclozolin and iprodione were not.

INTRODUCTION

Historically, the fungicide chlorothalonil has been used routinely to control Phoma blight of Douglas-fir, caused by Phoma sp., and Sirococcus tip blight of pine, caused by Sirococcus strobilinus, at the USDA Forest Service Humboldt Nursery in coastal northern California. In 1981, clorothalonil was detected in a tributary stream adjacent to the Nursery. The stream receives overflow from sumps containing drainage and runoff water from production beds during periods of peak rainfall. The use of the fungicide at the Nursery was then terminated. In 1982 losses in Douglas-fir and pines increased, and a previously minor disease of red fir caused complete economic loss of the crop. The suspected causal agent, which is morphologically identical to the species causing Phoma blight of Douglas-fir, was Phoma eupyrena.

Subsequently, Forest Pest Management, in cooperation with the University of California at Berkeley, initiated a study to 1) find an efficacious chemical control for Phoma blight of red fir, and 2) determine the efficacy of fungicides other than chlorothalonil for the control of Sirococcus tip blight of Jeffrey pine.

MATERIALS AND METHODS

Fungicide evaluation tests were conducted on a 4 ft-wide by 500 ft-long bed of 1-0 red fir and a 4 ft-wide by 200 ft-long bed of 1-0 Jeffrey pine at the Humboldt Nursery. Ten fungicides on red fir and five fungicides on Jeffrey pine were evaluated at the recommended label dosages (Table 1). The fungicides were mixed with water at the dosages shown and applied to appropriate plots at the rate of 1 gallon per 200 ft^2. Fungicides were selected because of past effectiveness against Phoma and Sirococcus (Smith, et. al., 1972; Smith, unpublished data) or recently demonstrated systemic activity against other diseases.

The experimental design used was alternating treated and untreated plots (4 x 5 ft) with the test fungicides assigned randomly to every other plot, giving a system of paired plots (treated and untreated) in which the treatments were randomly placed. This system was replicated five times down the bed of red fir (100 plots total) and four times down the bed of Jeffrey pine (40 plots total).

Treatment began in September, 1982 and continued at approximately one month intervals until May (red fir) or June (Jeffrey pine) of 1983. Dead red fir and cankered Jeffrey pine were counted and removed from each plot monthly. At the termination of each experiment, all remaining seedlings were counted to obtain a total count per plot, and percentage of seedlings killed (red fir) or cankered (Jeffrey pine) was determined. Percentages underwent arcsine transformation for data analysis and a t-test was used to determine statistical differences between paired plots.

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Table 1. Fungicides and application rates evaluated at the Humboldt Nursery.

	Common Name[a]	Trade Name	Rate/100 Gal. Water
1.	chlorothalonil	Bravo W-75	2 lb
2.	captafol	Difolatan 4F	2 pt
3.	fixed copper	Copper Sulfate	3 lb
4.	mancozeb	Dithane M-45	2 lb
5.	benomyl	Benlate	8 oz
6.	triforine	Triforine EC	10 oz
7.	triadimefon	Bayleton	8 oz
8.	iprodione	Chipco 26019	1 1/2 lb
9.	vinclozolin	Ornalin	1 1/2 lb
10.	ectaconazole	Vangard	20 oz

[a] All ten fungicides were evaluated for control of Phoma blight of red fir. Chlorothalonil, triadimefon, iprodione, vinclozolin, and ectaconazole were tested for control of Sirococcus tip blight of Jeffrey pine.

RESULTS AND DISCUSSION

Phoma Blight of Red Fir

Disease was not apparent in any of the treated or untreated red fir plots until January, when a pocket of Phoma-infected seedlings became evident in one plot being treated with triadimefon. By March, prolonged periods of heavy rainfall (about 40 inches total in December, January and February) had resulted in the buildup of soil cones at the base of most seedlings and the spread of the disease, downslope, through the bed.

Results for March, April and May are presented in Table 2. Although the disease was active throughout most of the bed in March, there were fewer dead seedlings in plots treated with captafol, chlorothalonil, mancozeb and fixed copper than in adjacent untreated plots. By April, only plots treated with captafol, mancozeb and fixed copper had statistically significant fewer dead seedlings than adjacent untreated plots. By May, no significant differences between any fungicide treatment and adjacent untreated plots were present. Plots treated with benomyl or the newer systemic fungicides had as many, or more, diseased seedlings than adjacent untreated plots throughout the experiment.

None of the fungicides tested effectively controlled Phoma blight of red fir. The disease was also active at high levels in adjacent production beds of red fir treated with chlorothalonil. The winter was abnormally wet, however, and chlorothalonil or other fungicides may control the disease during years of more normal precipitation or if applied at higher concentrations. More frequent application may also be effective, but this was not possible this last year because of the persistent rain. In fact, production beds and the experimental bed went untreated for 8 weeks in January and February because of almost daily rainfall. This 8-week period coincides with the time that the disease first appeared and subsequently spread rapidly through the experimental bed.

Other alternatives, including mulching or covering the beds to reduce rain splash and soil cone formation, are feasible, but expensive. The preferred alternative for effective control may be to grow red fir at the Forest Service Placerville Nursery, located in the foothills of the central Sierra, where annual rainfall is 42 inches compared to 60 inches at Humboldt.

Table 2. Percentage of red fir seedlings killed by *Phoma eupyrena* at the Humboldt Nursery.

Treatment	Total Percent Dead, By Month			
	February	March	April	May
chlorothalonil	3	8*[b]	33	85
untreated[a]	2	16	44	86
captafol	1	1*	9*	69
untreated	1	8	37	88
fixed copper	1	5*	18*	79
untreated	2	12	37	88
mancozeb	1	7*	33*	90
untreated	3	22	50	86
benomyl	2	10	42	90
untreated	2	9	52	92
triforine	1	20	36	80
untreated	2	20	41	86
triadimefon	4	24	55	92
untreated	2	20	56	89
iprodione	2	7	30	90
untreated	2	13	40	88
vinclozolin	1	13	40	88
untreated	2	15	50	92
ectaconazole	1	5	32	92
untreated	2	7	43	93

[a]Each entry is the average percentage of infected seedlings in the two untreated plots adjacent to the fungicide treatement listed directly above. Based on five replicates.

[b]Significantly different (P= 0.05) from the adjacent untreated plots listed directly below; Student's t.

Sirococcus Tip Blight of Jeffrey Pine

Although scattered infections appeared in both treated and untreated plots throughout the winter months, most cankering occurred in April and May when warmer spring storms arrived. By June, the disease had spread throughout the experimental bed, but differences in infection levels among treatments were obvious.

Chlorothalonil, as expected, was efficacious (Table 3). An average of 2% of the seedlings were cankered in plots treated with chlorothalonil, compared to 47% in the adjacent untreated plots. Ectaconazole and triadimefon also effectively controlled the disease. Plots treated with ectaconazole and triadimefon had 3 and 5% of the seedlings infected, compared to 46% and 57% infection in adjacent untreated plots. Plots treated with vinclozolin and iprodione had more infected seedlings than adjacent untreated plots; iprodione appeared to increase disease levels.

Table 3. Percentage of Jeffrey Pine seedlings infected by *Sirococcus strobilinus* at the Humboldt Nursery.

Fungicide	Treated[a]	Untreated[b]
chlorothalonil	2*[c]	47
ectaconazole	3*	46
triadimefon	5*	57
vinclozolin	66	60
iprodione	76	54

[a] Average percentage of infected seedlings in four replicate plots.

[b] Average percentage of infected seedlings in two adjacent untreated plots. Based on four replicates.

[c] Significantly different (P=0.05) from the adjacent untreated plots listed in the right column; Student's t.

Triadimefon is being considered by Humboldt Nursery as an alternative to chlorothalonil for the control of Sirococus tip blight. Additional tests to determine the most effective frequency and rates of application of ectaconozole and triadimefon will be conducted at the Nursery in 1984.

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A PRELIMINARY LOOK AT ANIMAL VECTORS OF LODGEPOLE PINE DWARF MISTLETOE

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Abstract

Establishment of *Arceuthobium americanum* infections beyond the normal range of seed expelled from explosive fruits indicates involvement of vectors. A study on the Fraser Experimental Forest in Colorado identified 8 bird and 3 mammal species as potential vectors. All told, 320 birds (including retraps = IRT) of 28 species, and 100 mammals (IRT) of 4 species were trapped and examined. Seven percent of the birds and 18 percent of the mammals carried seed. During a 16-day peak seed-dispersal period at one site, 22 percent of the birds (N = 55, IRT) and 20 percent of the mammals (N = 80 IRT) carried seeds. Important vectors appear to be the least chipmunk, gray jay, and Steller's jay.

Introduction

Although the occurrence of isolated dwarf mistletoe infection centers indicates that vectors are involved in their long-distance spread, little definitive data are available. An exception is for *Arceuthobium pusillum* on black spruce in the Lake States (Ostry et al. 1983). THese studies show that, during the seed dispersal period, 10 to 30 percent of the animals captured had seeds on their bodies. Animals with most seeds were gray jay, warblers, dark-eyed juncos, red squirrel, and flying squirrel. Birds and squirrels use mistletoe-infected trees for nesting and food gathering, but apparently do not eat dwarf mistletoe seeds. Birds with mistletoe seeds were found more than 140 m (460 ft) away from the closest infested stands. Hudler et al. (1979) conducted similar studies in a ponderosa pine forest infested by *A. vaginatum* in Colorado. Thirty-two isolated infection centers were found in a 340 ha. (840 acre) study area. Infection centers ranged from 20 m to 400 m (66-1,300 ft) from the closest infection source. Only 3 percent of 411 birds captured during the dispersal period carried seeds. Birds that were the most frequent carriers were pygmy nuthatch, mountain chickadee, and gray-headed junco. Zilka and Tinnin (1976) studied bird-dwarf mistletoe relationships in the Pacific Northwest. They too, concluded that birds do not eat dwarf mistletoe seeds but that long-distance dispersal occurs through external seed transport.

Methods

This study was conducted on the Fraser Experimental Forest near Winter Park, Colorado. The forest is predominately lodgepole pine. The 1982 studies concentrated on trapping birds (mist nets) and animals (cell traps) at 3 sites (9,000, 9,400, and 10,000 feet). At each site, dwarf mistletoe seed dispersal was monitored by making daily counts of 2- by 2-feet seed traps on the ground near infected trees. A total of 50 traps was used in the three sites.

Results

Seed Dispersal

Seed dispersal was monitored from August 18 to September 19, 1982. The results are summarized in Table 1. Information on peak dispersal was obtained only from the 9,000-foot site because record keeping at the other two sites was stopped before the dispersal period was over. At the 9,000-foot site, 75 percent of the seed was dispersed during the 10-day period between September 2 and 11. At the 9,400-foot site, peak dispersal began on September 8 and was continuing at a relatively high rate until September 19. At the 10,000-foot site, dispersal was irregular, without a peak, from August 23 to September 19.

Birds

In all, 320 individuals (including retraps) of 28 psecies were trapped. Eight species of birds carried dwarf mistletoe seeds (Table 2). Seven percent of the birds caught during the entire study period had seeds. However, during the 16-day period of peak seed dispersal at the 9,000-foot site, 22 percent of the 55 birds trapped had seeds. Birds with the highest proportion of seed were Steller's jay, gray jay, northern 3-toed woodpecker, and mountain chickadee.

Mammals

In all, 100 individuals (including retraps) of 4 species were trapped. Three species carried mistletoe seeds (Table 1). Eighteen percent of the mammals caught during the entire study period had seeds. However, during the 16-day period of peak seed dispersal at the 9,000-foot site, 20 percent of the 80 mammals trapped had seeds. Least chipmunks and golden-mantled ground squirrels carried the most seeds. Our sample was too small to evaluate seeds on pine marten (1 of 1 with seed) or red squirrel (0 of 4 with seed).

Conclusions

Ths preliminary study has shown that at least 11 animal species carry lodge-pole pine dwarf mistletoe seeds--8 birds and 3 mammals. The most important potential vectors are Steller's jay, gray jay, and least chipmunk. For the entire study period, 10 percent of the animals (N = 420) carried seed (birds 7 percent and mammals 18 percent). During the peak dispersal period at one site, 21 percent of the animals carried seed (birds 22 percent, and mammals 20 percent).

Thus, this study has established that birds and mammals can carry dwarf mistletoe seeds but the role of animals in long distance dispersal has not been quantified. This is one of the primary objectives of follow-studies planned for the Fraser Experimental Forest in 1983. We plan to make detailed surveys to map dwarf mistletoe distribution in the study area, including location of satellite infection centers established beyond the range of explosive seed discharge. We plan to continue trapping birds and mammals. Also, radio telemetry is planned to monitor movement of animals between infested and unifnested stands.

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EVALUATION OF A DWARF MISTLETOE ROADSIDE SURVEY PROCEDURE

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INTRODUCTION

Information regarding the intensity, distribution, and impact of dwarf mistletoes (Arceuthobium spp.) is needed to assist the land manager in making intelligent management decisions. Surveys have provided much of this needed information. Dwarf mistletoe surveys have routinely incorporated plot survey information, designed to assess cubic-foot-volume data, with roadside reconnaissance surveys, which determine incidence.

During the summer of 1981, a dwarf mistletoe roadside reconnaissance and plot survey was conducted throughout ponderosa pine stands in Colorado. The discontinuity of the ponderosa pine type led to a high proportion (47.6%) of the plots being located in non-ponderosa pine areas. Only 11.6% of the ponderosa pine plots established were infested with dwarf mistletoe, while the roadside survey showed that approximately 19% of the ponderosa pine type was infected. These comparisons raised questions as to the accuracy of the roadside reconnaissance method. The objective of this study, therefore, was to evaluate the validity of the roadside reconnaissance survey used to estimate the proportion of ponderosa pine type in Colorado infested with dwarf mistletoe.

MATERIALS AND METHODS

The 1982 road/plot study areas were selected in ponderosa pine type in the Roosevelt, Pike, and San Juan National Forests in Colorado. Sections of road 1.6 km in length were surveyed along the right-hand side, and categorized as follows:

1) None - no visible infection.
2) Low - less than 1/3 of that strip infested.
3) Medium - 1/3 to 2/3 of that strip infested.
4) High - over 2/3 of that strip infested.

Three study areas in each of the four mistletoe infection categories were located in the three national forests.

Within each study area, a row of variable-radius (BAF10) plots were established 40 meters from and parallel to the surveyed side of the road, at approximately 100 m intervals. Linear regression analyses of the data were used in comparing the proportion of roadside infested to the proportion of plots infested with dwarf mistletoe. Data were analyzed by national forest, and then combined to achieve a total average regression equation. Data were also grouped according to the dwarf mistletoe infection categories, and were analyzed using a paired T-test to determine if mean percentages of roadside and plots infested were similar in each of the four categories.

RESULTS AND DISCUSSION

In each forest sampled, the abundance of A. vaginatum observed from the road generally agreed with the percentage infested 40 meters into the forest. Results indicate a significant association between the percentage of roadside and plots infested with dwarf mistletoe on the Roosevelt, Pike, and San Juan National Forests (R^2 = .85, .96, and .88, respectively) (Table 1). The average R^2 value for all these forests was .88.

Using a paired T-test, no significant differences were found between roadside and plot means in each of the four dwarf mistletoe infection categories. Each category of roadside infestation adequately predicted the amount of dwarf mistletoe infestation occurring 40 meters into the forest.

Table 1.--Linear regression equations relating the percentage of roadside infested (X) to the percentage of plots (Y) with dwarf mistletoe.

National Forest	Equation
Roosevelt	$Y = 0.94x - 3.85$
Pike	$Y = 0.83x + 4.15$
San Juan	$Y = 0.88x - 0.674$
Total average	$Y = 0.88x + 0.072$

CONCLUSIONS

The roadside reconnaissance survey provides an adequate estimate of the proportion of P. ponderosa infested with dwarf mistletoe. The roadise survey procedure provided data that were highly correlated to percentages of plots infested (based on R^2 values) in all three national forests surveyed, without bias according to the dwarf mistletoe infection categories assigned from roadside observations. The roadside survey procedure, therefore, is an accurate method, useful in quantifying the abundance and distribution of dwarf mistletoe in ponderosa pine stands, provided that roads are sufficient to represent the stands that are sampled.

RELATIONSHIP OF PONDEROSA PINE DWARF MISTLETOE WITH HABITAT TYPES AND OTHER ECOLOGICAL FACTORS

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INTRODUCTION

Dwarf mistletoes of the genus Arceuthobium are the most damaging disease agents of the coniferous forests of western North America. While the distribution and severity of the dwarf mistletoes have been shown to be related to the character of vegetation and other ecological factors, no previous attempts have been made to observe the relationships of these factors with A. vaginatum in Colorado. Therefore, the objective of this study was to assess the relationship between the frequency and severity of ponderosa pine dwarf mistletoe and habitat types and other ecological factors.

MATERIALS AND METHODS

The dwarf mistletoe study areas were located in three National Forests in Colorado--the Roosevelt, Pike, and San Juan. Sections of road 1.6 km in length were surveyed along the right-hand side, and categorized as follows:

1. None - no visible infection.
2. Low - less than 1/3 of that strip infested.
3. Medium - 1/3 to 2/3 of that strip infested.
4. High - over 2/3 of that strip infested.

A row of variable-radius (BAF10) plots was then established 40 meters from and parallel to the surveyed side of the road, at approximately 100 m intervals. Tree information collected included species, condition, d.b.h., height, and dwarf mistletoe rating (DMR). Site index and basal area were also determined. Habitat types were identified by using keys developed by Terwillinger et al. and Hess, and were recorded on a habitat type form adopted from Steele et al.

The eight habitat types observed in this study, with their respective abbreviations were: Pinus ponderosa/Carex rossii (Pipo/Caro), P. ponderosa/Cercocarpus montanus (Pipo/Cemo), P. ponderosa/Festuca arizonica (Pipo/Fear), P. ponderosa/Hesperochloa kingii (Pipo/Heki), P. ponderosa/Muhlenbergia montana (Pipi/Mumo), P. ponderosa/Purshia tridentata (Pipo/Putr), P. ponderosa/Quercus gambelii h.t. - Mahonia repens phase (Pipo/Quga-Mare), and P. ponderosa/Quercus gambelii h.t. - Symphoricarpos oreophilus phase (Pipo/Quga-Syor). Those habitat types which could not be identified were grouped into an "unknown" category.

Chi square tests and a logistic regression model were used to test the relationship between habitat type and ecological information and dwarf mistletoe frequency. Linear regression and an analysis of variance were used to analyze the dwarf mistletoe severity data.

RESULTS AND DISCUSSION

This study suggests that A. vaginatum occurs most frequently on the driest ponderosa pine sites becuase dwarf mistletoe was significantly more frequent where the Pinus ponderosa/Muhlenbergia montana h.t. occurred. Pipo/Mumo habitat type, composed of xerophytic grasses, along with the Pipo/Cemo habitat type, occupy the most xeric environments associated with ponderosa pine. Many of the ecological factors associated with the Pipo/Mumo and Pipo/Cemo habitat types were also the most commonly associated with high dwarf mistletoe frequency, i.e., moderate slopes, medial elevations, ridgetop and upper slope topographies, convex configurations, southerly aspects, moderate site indices and low basal areas ($<1.5m^2$/ha).

This study revealed that where A. vaginatum was most frequent, the parasite was usually most damaging as well. The Pipo/Mumo h.t. displayed the highest average DMR. Dwarf mistletoe severity, like frequency, was highest on sites with moderate slopes, dry and exposed ridgetops, and upper slope topographies, convex configurations, low site indices (50-59) and low basal areas.

CONCLUSIONS

This study shows that definite patterns exist where ponderosa pine is more frequently and severely infested with *A. vaginatum* than other areas. Data indicate that dwarf mistletoe is flourishing in the warmer and drier environments that also support the growth of ponderosa pine. The habitat type classification scheme proved useful in identifying these areas, as did many of the ecological factors that were also common constituents of the xeric *Pinus ponderosa/Muhlenbergia montana* habitat type.

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THE INTEGRATED PEST IMPACT ASSESSEMENT SYSTEM AS A FRAMEWORK FOR A COMPREHENSIVE FOREST MANAGEMENT INFORMATION SYSTEM

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ABSTRACT

Forest planners and managers, pest management specialists, and other resource specialists are in need of more efficient and effective means for evaluating implications of alternative management actions. Computerized systems to assist in impact evaluation can take one of two forms: (1) decisionmaking; or (2) information assimilation and presentation. The Integrated Pest Impact Assessment System (IPIAS) provides information assimilation and presentation and, because of its modular design and inherent versatility, can be used for virtually any forest management problem.

A new computer-assisted forest management information system is being developed, called the Integrated Pest Impact Assessment System (IPIAS). As the name implies, IPIAS consists of a linked set of models, data bases, and computer programs, developed in the context of pest management concerns, specifically mountain pine beetle (MPB, Dendroctonus ponderosae Hopkins) impacts in Colorado. However, as IPIAS evolved, a framework emerged that offers considerable promise as a more general forest management and planning tool. This paper describes the development of IPIAS and illustrates some of the capabilities of the current version of the system.

DEVELOPMENT OF IPIAS

IPIAS was developed during a particularly dynamic period in the evolution of forest planning methods and related technology. There were substantial, rapid changes in forest planning and management procedures in the last decade in response to a number of legislative and public mandates and perceived needs within land management agencies. Interdisciplinary teams of resource specialists have undertaken comprehensive plans for the management of large heterogeneous tracts of forest land. Forests are routinely measured, mapped, and managed in terms of many interacting, and often conflicting, concerns. This has resulted in a large increase in data and data management efforts, forest-effect simulation capabilities, and multiple objective decisionmaking systems.

During this same time period, there were tremendous advances in computer hardware and software used in forest planning and management. In many respects, this was a mutually beneficial relationship, with new management needs stimulating advances in computer technology, and new computer technology opening additional areas of management capabilities. In a very short time period computer keyboards and CRT's have become standard equipment for forest managers.

Different components of on-line forest planning and management have had varying success in keeping up with the rapidly changing information processing capabilities and requirements. Most National

Forests have computerized data bases (i.e., SYSTEM 2000, also referred to as S2K), especially for timber management. One or more stand (or tree) growth models are routinely used to systematically project the implications of alternative silviculture activities. National Forests also use multiple-objective optimization programs (FORPLAN, Johnson et al. 1980) in their planning and decisionmaking. However, few quantitative computerized models exist that include wildlife, recreation, or scenic quality components. Even fewer models are capable of responding accurately to projected changes in specific forest characteristics.

Much of the impetus for the development of IPIAS is related to MPB impacts on ponderosa pine (Pinus ponderosa Laws) along the Front Range of the Colorado Rockies. Forest managers needed to develop treatment strategies that could effectively salvage damaged stands, control the MPB in currently infested stands, and protect susceptible stands. The benefits to be derived, in terms of traditional timber economic values, were not of major significance in the affected region (Averill et al. 1977). In fact, the principal factor motivating MPB control was the significant scenic value of the area and its' major public use for recreation, tourism, and vacation home development. The capabilities to accurately project how these values might be affected by both insect- or treatment-induced changes in forest characteristics was nonexistent.

Preliminary testing and extensive discussions with forest planners and managers indicated the need to carry IPIAS several steps beyond the first generation system. The next step was to link the IPIAS models to a forest stand model that would project growth and mortality as influenced by silvicultural treatments and effects of insect and disease pests. Perhaps the most significant step, however, was to add a geographic or spatial information component to IPIAS.

Tabular data (such as that used and produced by IPIAS) must be related to distinct spatial locations for effective forest planning and management. Typical forest offices contain a great deal of spatial data, in the form of maps transcribed from aerial photographs. Accessing this type of spatial data is often a significant task. Finding the desired map is usually only the first step in the data retrieval process. The maps may contain a color or numerical code (or both) that refer to tabular or textual data stored in another information system, such as computer files or more often, other hard copy material. In addition, significant changes may have occurred in the area since the maps were prepared; these changes may not have been noted on the map or in associated textual or tabular material.

Suppose inspection of the referenced tabular data reveals a change in status for the mapped unit. For example, new (Stage II) data reveals that what was classed as a pole sized douglas fir stand is actually a mature lodgepole pine stand. Who's got the purple "magic marker"?

This type of information display and analysis is inefficient, offers a great many opportunities for error, and is extremely cumbersome and time consuming to update or correct. Even so, considerable forest planning and management work is done using some version of this type of system and there has been observable progress toward streamlining and improving the related procedures.

The second generation of IPIAS was designed as an impact assessment and information system that would be adaptable to changing forest management and planning processes. Few of the system components are new. In many respects, IPIAS simply represents the integration and computerization of procedures that are now largely carried out manually by many forest planners and managers. The development of this type of interactive computerized information system is a logical step if forest planning and management activities are to meet the ever increasing requirements for data quantity and quality, documented evaluation and decision making processes, and effective monitoring of progress toward management objectives.

COMPONENTS OF IPIAS

IPIAS was designed to provide forest planners and managers, pest management personnel, and other resource specialists with a method to efficiently and effectively evaluate the implications of alternative management actions. Currently, the system focuses on predicting forest changes associated with MPB damage and related control activities. However, because of its modular design and versatility, IPIAS is potentially useful for a much wider range of forest pests. In fact, IPIAS is applicable to nearly any management problem where changes in forest characteristics can be described or modeled.

IPIAS is composed of three major subsystems (figure 1): (1) a geographic information system (GIS); (2) a data base management system (DBMS); and (3) a set of pest, forest and socioeconomic prediction models. The GIS contains spatial data, such as forest and stand boundaries, public land survey lines, and recreation sites. The DBMS has all of the textual and tabular data pertinent to each timber stand in the GIS in memory. The predictive models are used to determine the forest changes that could result from alternative management actions. These three subsystems, integrated into an interactive computer system (figure 2), become a very versatile and responsive management tool.

The principal components and features of each subsystem in IPIAS are described below. Specific components and models currently used in IPIAS are adapted to the MPB in the Colorado Front Range. However IPIAS' modular format allows other models and data bases to be readily substituted into IPIAS for applications to other forest and pest types. The basic form of the system, however, would remain the same.

Data base management system. A DBMS facilitates the automated storage and retrieval of textual and tabular data. The DBMS used in IPIAS is a general purpose one, called SYSTEM 2000 or S2K. The U.S. Forest Service has used S2K for storing and analyzing timber sale accounts and timber management systems since 1975. S2K utilizes a user-oriented English-like language that enables a nonprogramer to easily build, access, and manipulate a data base. S2K can be accessed interactively or in a batch mode, and the user can define a new data base, or modify an existing one. S2K also has data reduction and analysis capabilities.

Every National Forest in the United States has a data base in S2K[1]. The most numerous data

[1] S2K is maintained by the USDA on a mainframe computer in Fort Collins, Colorado. Each forest accesses S2K via telecommunication.

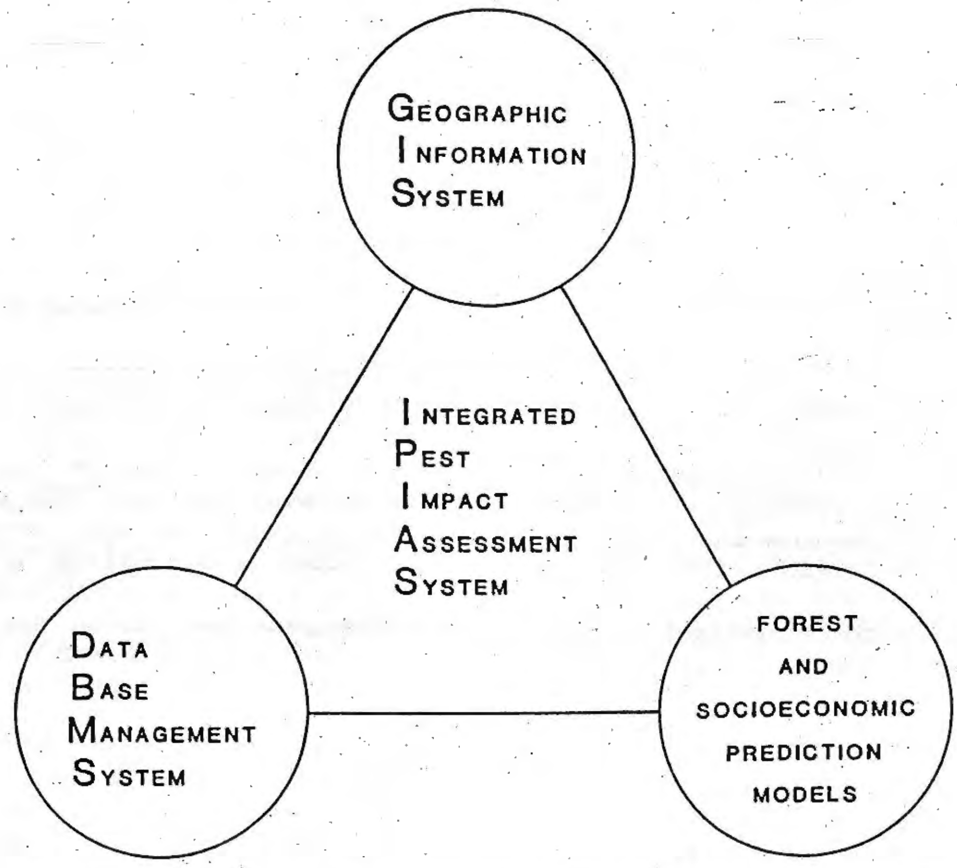

Figure 1 - General diagram of an Integrated Pest Impact Assessment System.

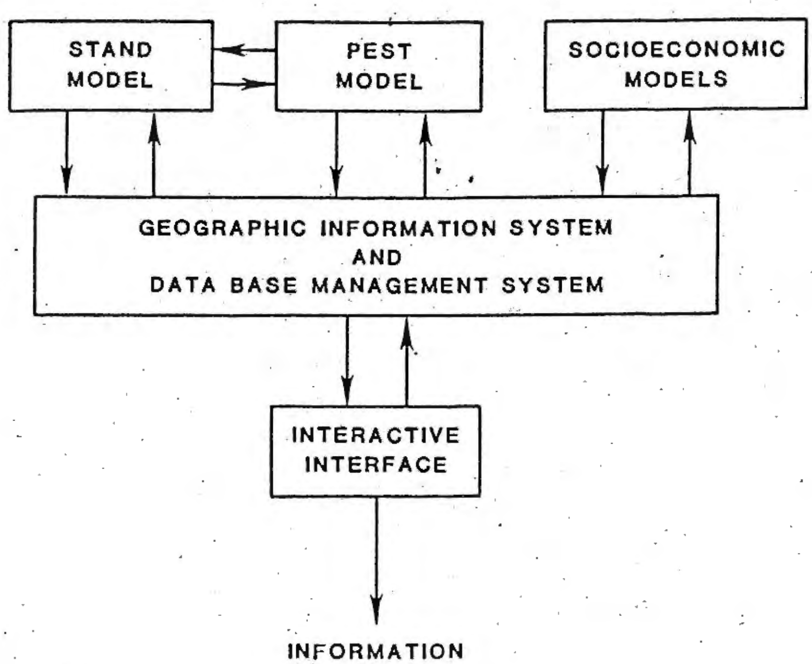

Figure 2 - Basic operating structure of IPIAS.

relate to forest land resources, including recreation potential, soil types, wildlife data, and timber stand data, such as that used in the IPIAS models. S2K can store geographic identifiers, such as latitude-longitude coordinates, or narrative location descriptions. However, graphically displaying this spatial data requires a geographic (spatial) information system.

Geographic information system. A GIS, deals primarily with spatial or geographic data, rather than with textual or tabular data. In general, a GIS does not have to be an automated system; e.g., a map file or a world atlas could be considered a GIS. In recent years, however, the amount and complexity of resource data necessitates some degree of automation.

A computerized GIS consists of three basic subsystems: (1) data capture; (2) data analysis; and (3) data output. In the GIS, data is usually captured or copied into the computer utilizing a coordinate system that retains the geographic integrity of the resource data. The analytical component manipulates the original map data to produce any additional information specified by the user. The output component allows the user to reproduce the original data or derived data on a graphics terminal screen or as a "hard copy" map, chart, or graph.

A typical computerized GIS data base contains a number of different types or "themes" of data, usually pertaining to the same geographic area. Map or cartographic data, such as public land survey lines, topographic features, or other map-related features with locational or spatial attributes are the types of data most commonly included in a natural resource data base. The data base may also contain other types of data such as sites of archaeological interest, important big game ranges, recreation sites, or location of pest outbreaks. When several data themes are combined into one data base it is referred to as a "multiresource" data base; if all of the possible data themes are included, it is referred to as a "total resource" data base.

The computerized GIS performs many of the types of spatial manipulations traditionally performed manually, except that it is faster and more efficient (Goulet et al. 1981, Tomlin et al. 1981). In addition, the GIS can be used for the logical or arithmetic compositing of many maps at one time, a task that cannot easily be done manually.

The GIS component of IPIAS is the Map Overlay and Statistical System (MOSS), developed by the U.S. Fish and Wildlife Service's Western Energy and Land Use Team[2]. MOSS currently operates in a minicomputer environment, which gives users on-site access and control.

There are currently over 100 analytical commands in MOSS, and map analysis can occur in either vector (polygon) or raster (cell) modes. A number of data sources can be used in MOSS, including digital terrain models and satellite imagery such as LANDSAT. For each point, line, or polygon on a map, there can be up to 30 characters of identifying information, e.g., soil type, town, and geologic strata. The 30 character limit was expanded in IPIAS to accommodate the multiple

[2]The MOSS software, which is in the public domain, is supported by the U.S. Fish and Wildlife Services Western Energy and Land Use Team and the U.S. Bureau of Land Management's Denver Service Center.

fields of data for each timber stand stored in the corresponding S2K data file. The ability to manipulate and display the spatial characteristics of S2K timber stand data with MOSS, the multiple resource data themes possible in the GIS data base, and the capability for predictive model outputs were the final links needed to meet the objectives for IPIAS.

__Forest and socioeconomic prediction models.__ A number of separate prediction models are used in IPIAS to project the effects of management actions over time. A basic stand growth and mortality model is integrated with a pest effects model to predict changes in forest characteristics that would result from various silvicultural and pest-related activities. The resulting stand characteristics are used as input data for a set of models that predict an array of socioeconomic effects.

Because most forest management actions result in some change in the numbers, species, and sizes of trees, all of the components in IPIAS depend, in some way, on the output from the STAND model. The STAND model provides projections of future forest conditions based on initial inventories, growth and mortality parameters appropriate to the stand, and any prescribed management changes such as thinning or harvesting. The precision and level of detail of these projections determines the capabilities of the other models in IPIAS. Generally, stand tables should include at least numbers, sizes, and species of trees if estimates of pest susceptability, scenic quality, or economic products are needed. More precise predictions of the biological and socioeconomic effects of forest changes can be made if a more comprehensive forest ecosystem similator, including data on understory vegetation, down timber and slash, and quantity and quality of water runoff, is available.

The STAND model currently used in IPIAS is an adaptation of GROW (Anonymous 1983a). This model is used extensively for Front Range National Forests, especially previously unmanaged stands. GROW provides predictive stand tables, in 2-inch diameter classes, and volume computations for 10-year time periods. The user can specify a variety of management actions, in terms of types of thins or cuts and when they occur. Residual stand conditions are used as input to pest and socioeconomic models at each specified time period. The STAND model was modified to maintain tree species identification and to allow interaction with the MPB model component at annual time periods.

The PEST model projects any growth reductions and mortality in stands of a host species due to the activities of a particular pest over time, based on timber stand information from the STAND model. The PEST model typically uses information on the effects of variations in the size and density of the host species on stand susceptability, pest population dynamics during and between outbreaks, and the susceptibility of adjacent stands in the future due to their proximity to currently infested stands. The interaction between the STAND and PEST models must be linked to a time cycle that is appropriate for the dynamics of the subject pest. For example, some diseases may require a 5- to 10-year cycle, while some insect pests, because of their dynamic nature, may require a yearly cycle.

In the current MPB version of IPIAS, the PEST model is a generalized model that reflects expert opinion. The model is "triggered" by a combination of host and pest characteristics including stand density, current faders[3], green infested trees (trees that will fade next year), and estimated attack ratios. The MPB model provides estimated numbers of dead pines in 2-inch size classes on an annual cycle as input to the STAND model.

The socioeconomic models consist of a set of equations that relate forest characteristics to the various economic, recreation, and aesthetic values being estimated. Some of these models are straightforward and based on tested relationships; e.g., the model that predicts the present worth in dollars of a standing volume of sawtimber. Given accurate estimates of the number and size of trees in the residual stand, from the STAND and PEST models, computations involving volumes, prices, and discounts to get present worth are direct and readily accepted. Other models, such as those that estimate various types of recreation potentials, or public perception of scenic beauty are less well established. Still, the principal is the same: statistical relationships between forest characteristics, such as the sizes, species, and densities of trees and the amount of insect damage and recreation use or perceived scenic beauty are used to develop models (Schroeder and Daniel 1981, Walsh et al. 1981, and Buhyoff et al. 1982). Once developed, these models can be used to provide estimates of recreation potential and scenic beauty, based on projections of the characteristics of the residual stands.

IPIAS contains several sets of socioeconomic models developed specifically for the Colorado Front Range. Economic input-output models for three Front Range communities estimate the local effects of changes in income from forest industries, tourism, and "foot loose" residents (retirees and commuters) that result from changes in forest quality (tree density and insect damage). Other models estimate the effects of changes in forest quality on residential property values and potential for recreational use. Scenic quality models estimate the effects of forest change in terms of on-site (within the canopy of the affected forest) and vista perspectus. Depending on user needs any or all subsets of socioeconomic effects can be displayed.

SUMMARY

Although IPIAS is not an "on-the-shelf" system ready for wide application in forest management, many of its components are in extensive use by forest managers in the U.S. Forest Service and by personnel in other land management agencies as well. MOSS, S2K, and the GROW model are widely used. Many of the economic model components are based on accepted price and discount functions and, therefore, have wide application. Some components, such as the scenic value models, have been extensively tested in the Front Range area, but may not be applicable beyond that set of forest conditions. The MPB model component requires additional testing and development, as do most of the socioeconomic models. The general framework, however, works very well and potentially can be of tremendous benefit to forest managers and planners.

Implementation of an IPIAS-type system within current forest management and planning procedures could take a form similar to that in

[3] "Fader" is a colloquial term for a ponderosa pine tree having a discolored (yellow/orange) appearance which results from attack by the mountain pine beetle.

figure 3. The starting point is always an inventory of relevant forest resources. The inventory must be complete enough to operate the STAND model. In a typical IPIAS application, the timber staff and forest silviculturalist would run the STAND model, providing the needed parameters and formulating appropriate harvest, thinning, and pest management activities. Pest management specialists would provide up-to-date infestation or damage inventories and other parameters (e.g., attack ratios for insects) needed to integrate the PEST model with the STAND model. Output from the STAND model would drive a set of resource models, each operated and interpreted by the appropriate planning or management specialist. For each modeled management alternative, resource specialists would provide their evaluation and recommendations, supported by the related model projections of location, timing, and magnitude of predicted effects.

IPIAS was designed to augment existing forest planning and management procedures and to incorporate the interdisciplinary team, approach used in forest planning. The principal modifications of that process are the close link between the data base management and geographic information systems and the use of interrelated quantitative models. Mathematical stand growth and economic models are already routinely used and of great value to timber specialists and economists. Recreation, wildlife, and scenic value models are not generally available at this time. When developed and integrated into a comprehensive information system, such models can enhance the precision, reliability, and usefulness of incorporating socioeconomic variables in the forest planning and decisionmaking process. For now, projecting impacts of forest change on this type of variable must be based largely on the implicit, informal models used by individual resource specialists.

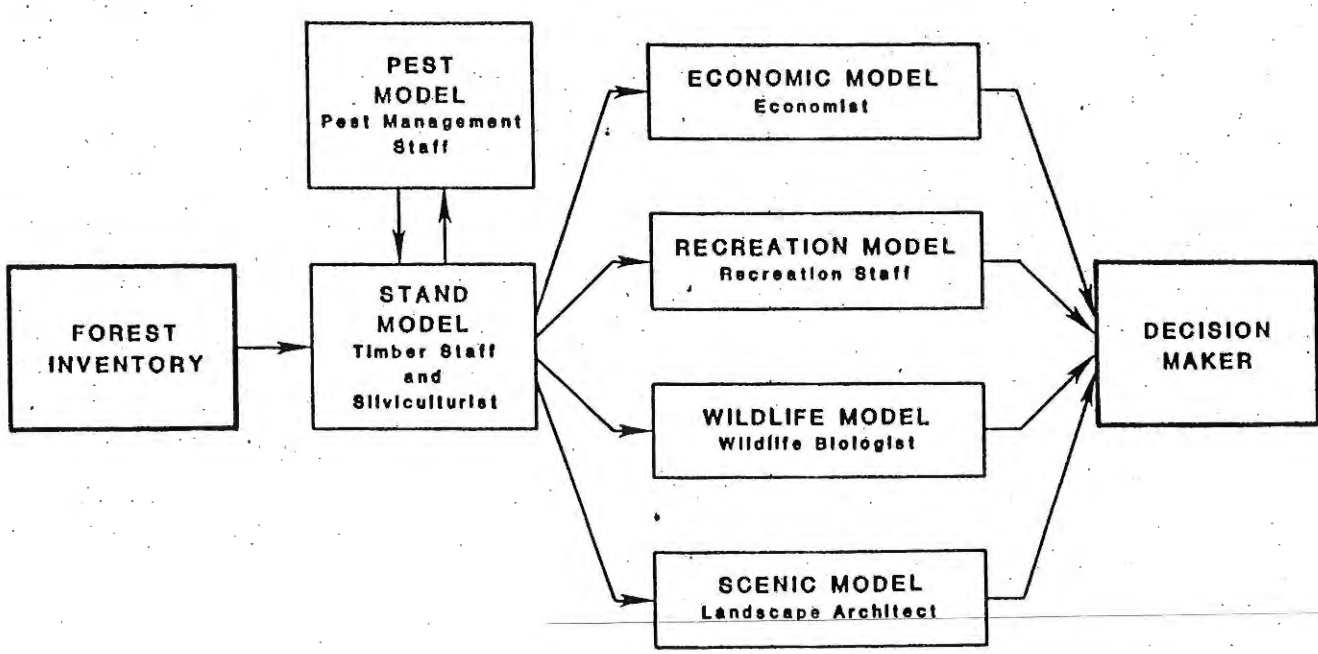

Figure 3 - Schematic outline of IPIAS as implemented within a general forest planning framework.

There are several different areas of forest planning where IPIAS could be a very useful tool for the forest manager. For example, the DBMS and GIS components can be used to facilitate compiling, analyzing, updating, and accessing basic inventory information at all stages of forest planning. IPIAS can be used in the identification and mapping of homogeneous analysis areas and in the formulation and selection of a set of candidate management strategies to be subjected to a FORPLAN decision model. The socioeconomic components of IPIAS can be used to facilitate setting appropriate constraints for FORPLAN and to provide a basis for directly including recreation and scenic considerations in the decisionmaking process. After general management goals and guidelines are determined through the FORPLAN process, IPIAS can be used to assign treatments to specific stands (project planning) and to monitor progress toward management goals. Because IPIAS is a "user friendly" interactive computer system, there is close interaction among all components of the planning process, increasing the value of the system for forest managers.

Forest Pest Management personnel of the USDA Forest Service sponsored a workshop in March 1983, to review and evaluate the MPB version of IPIAS and to develop a 5-year plan for future work. Over 40 forest planners, managers, resource specialists, and scientists from throughout the Nation participated in the workshop. While there was considerable discussion of the strengths and weaknesses of specific model components, there was concensus that the general IPIAS framework was valid and worthy of future effort. A 5-year research and development proposal has been drafted by Forest Pest Management personnel and is currently under consideration by Forest Service administration (Anonymous 1983b).

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COMANDRA RUST INTENSITY AND SEVERITY IN LODGEPOLE PINE

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DAMAGE SURVEY

The number and distribution of comandra rust-diseased lodgepole pine on the Wind River District, Shoshone National Forest, Wyoming, were estimated by cruising 21 randomly selected stands (6% of commercial forest area) in 1981-82.

The commercial forest of the Wind River District is dominated by stands of lodgepole pine and by stands of spruce-fir with some lodgepole pine and other species. The forest has an unregulated age distribution due to a scarcity of 20- to 50-year-old stands. Over 90% of the basal area is in trees larger than 12 cm dbh. Lodgepole pine makes up almost 40% of the basal area in all diameter classes except those larger than 36 cm.

Fifty percent of the lodgepole pine in mature stands were diseased. In 85% of rust-infected trees, cankers had killed the top of the crown. An average of 50% of the basal area of the pines larger than 12 cm dbh is classified as diseased. Most of 24-36 cm dbh poles are infected. The rust is least common among saplings. These younger trees have experienced few favorable inoculation periods and survive only for a short time after infection. Comandra rust has not yet infested the young stands which are generally less than 20 years old. Although uncommon on the forest and not included in the survey, several 25-year-old stands exist and these are rust infested. The rust is found on a lower percentage of lodgepole plots in mature mixed species stands than in mature lodgepole stands. Mixed species stands are at higher elevations and are further from the dry rocky slopes where the alternate host occurs which may account for the lower infestation.

From the damage survey on the Wind River District, a current description of rust-infected and healthy trees can be obtained. For diseased trees, the mean dbh is 24 cm, stem length is 16 m, and age is 100 years. The most commonly seen infected tree has a stem canker which is several decades old and which has killed the top third of the crown. Although healthy trees are about the same age and height, they average only 21 cm dbh. This difference can be explained if larger trees are more likely to become infected but still survive than are smaller trees.

VOLUME GROWTH

The effect of rust cankers on volume growth and stem form was investigated by destructively sampling trees. A series of disks were collected at various heights along the length of a bole. At each height, a mean radial distance was obtained for each year's growth since 1931. Stem profile was plotted as a set of annual curves of height over radius for individual trees. With this method a comparison of a typical rust-damaged tree with a healthy tree of the same age and from the same stand can reveal canker effects.

The representative healthy tree was 93 years old at stump height, 27 cm dbh, 17 m tall and had 12 m of live crown. Above the base, the radial increment had been generally constant along the bole for each year. Some suppression followed by release occurred in the early 1960's.

The representative damaged tree was 93 years old at stump, height 24 cm dbh, 15 m tall and because of a girdling canker which originated at a height of 10.4 m had only 0.6 m of live crown remaining. The rust was first evident on the stem in 1953, and five years later had completely girdled the bole. After two more years, the stem died above the canker center. The rust continued to grow proximally and ultimately reached 9.8 m above the ground. With such a serious loss of productive crown, radial growth was decreased by 80%.

Initially both trees had similar volume growth rates, but after crown loss the rate for the rust-damaged tree was significantly reduced. Although the damaged tree was previously larger, the healthy tree ultimately achieved a greater size.

RISK RATING LODGEPOLE PINE FOR CRONARTIUM COMANDRAE

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INTRODUCTION

Comandra rust is a damaging disease of lodgepole pine in certain high risk areas such as the Wind River District of the Shoshone National Forest, Wyoming. The biology of the rust fungus and disease is fairly well documented. Unfortunately, limited information is available on what factors characterize high risk stands and how the distribution of the alternate host Comandra umbellata affects the incidence of the disease in pine. The consequences of stand management are, therefore, unknown since there is no way to predict disease occurrence. This project, initiated in June 1983, will address these needs.

OBJECTIVES

1. Develop methods of hazard-rating for comandra blister rust infestations in the lodgepole pine forests of the Rocky Mountain Region.

2. Evaluate the ecological relationships between the distribution and biology of comandra rust on lodgepole pine and the alternate host Comandra umbellata.

METHODS

Field data on disease incidence and severity and site factors will be collected from infested and healthy stands in Colorado, Wyoming and Montana. Variable radius plots will be placed along transects to collect data on rust incidence and severity, incidence of other pests, dbh, tree age, density, canker age, etc. and site factors such as elevation, slope and aspect. Data will be mapped and analyzed for any relationship to regional parameters such as wind patterns or geographical location.

A survey of potential C. umbellata habitats will be conducted adjacent to surveyed pine stands. The effect of the distribution of C. umbellata on the incidence and severity of the rust will be determined by mapping the location of both hosts. The survey will also determine more closely the habitat of the comandra plant and the conditions favoring or inhibiting growth and spread of the alternate host. The effects of clear cutting, site preparation, grazing, fire, roadways and other forest and range sites will be assessed for their influence on the suitability of the sites as comandra habitats.

RESULTS

A majority of the Wind River District of the Shoshone National Forest, Wyoming, has been surveyed in 1983 for C. umbellata. Comandra was a common plant throughout the district on dry-sparsely-vegetated slopes.

Limited rust incidence and severity data was collected in 1983 by the cooperating Wind River District. No data analysis has been completed to date. The next field season will allow for the collection of additional C. umbellata location information and rust incidence and severity data in the Wind River District and in nearby national forests.

IMPACT AND DISTRIBUTION OF DWARF MISTLETOES IN MONTANA. Oscar J. Dooling, USDA Forest Service, P.O. Box 7669, Missoula, MT 59807

Dwarf mistletoes (Arceuthobium spp.) (DM) reduce tree height and diameter growth, and thereby reduce volume production. Recent surveys have measured this reduction and delineated distribution of the parasites on 3 hosts in Montana. A. douglasii causes an estimated annual reduction of 9 million cubic feet (MM ft^3), or about 12 percent of the total volume growth of Douglas-fir. A. americanum causes an annual reduction of 17 MM ft^3, or about 14 percent of the total lodgepole pine volume growth. A. laricis causes an annual reduction of 7 MM ft^3, or about 29 percent of the total western larch volume growth. Collectively, DM's cause an annual reduction of 33 MM ft^3, or about 15 percent of the total volume growth of the 3 host species. If this volume could be recovered, it could build more than 31,000 3-bedroom single family houses each year. The survey was a combination road-plot system described by Drummond (Drummond, D.B. 1978. USDA Forest Serv. Rpt. PSW-31, pp 55-61).

TRANSMISSION OF THE PINE WOOD NEMATODE, Bursaphelenchus xylophilus DURING OVIPOSITION OF Monochamus carolinensis, M. scutellatus and M. mutator. M.J. Wingfield and R.A. Blanchette. Department of Plant Pathology, University of Minnesota, St. Paul, MN 55108.

Pairs of Monochamus carolinensis, M. scutellatus and M. mutator in cages were allowed to oviposit on pine bolts for 4 to 8 weeks. Bolts were replaced weekly and nematodes extracted from oviposition niches. Nematodes were transmitted during oviposition by all three beetle species. Of 322 oviposition niches made by three pairs of M. carolinensis, 29 contained B. xylophilus. Four pairs of M. scutellatus made 286 oviposition niches of which seven contained nematodes while five pairs of M. mutator made 227 oviposition niches of which four contained B. xylophilus. The average number of B. xylophilus transmitted per pair of M. carolinensis, M. scutellatus and M. mutator examined was 96, 12, and 69, respectively. Transmission of B. xylophilus during vector oviposition explains the presence of the nematode in dying trees and cut timber in the United States.

THE PINE WOOD NEMATODE IN DWARF MISTLETOE INFESTED JACK PINE IN MANITOBA. T.A. Burnes, M.J. Wingfield, F.A. Baker, and D.W. French, Department of Plant Pathology, University of Minnesota; and K. Knowles and E. Beaubien, Department of Natural Resources, Winnipeg, Manitoba, Canada.

The pine wood nematode, *Bursaphelenchus xylophilus* (Steiner and Buhrer) Nickle was found in declining jack pine (*Pinus banksiana* Lamb.) infested with dwarf mistletoe (*Arceuthobium americanum* Nutt. ex Engelm.) All trees or tree parts containing *B. xylophilus* were also infested with cerambycid beetles (Coleoptera:Cerambycidae) and bark beetles (Coleoptera:Scolytidae). The nematode was not found in vigorous trees without mistletoe, or trees with living witches' brooms. Dwarf mistletoe appeared to be the primary cause of tree death, whereas bark beetles, cerambycid beetles and *B. xylophilus* were secondary colonists of the declining trees. *Bursaphelenchus xylophilus* has not previously been reported in Canada.

PATHOGENICITY OF *Verticicladiella procera* AND *Leptographium terrebrantis* IN GREENHOUSE AND FIELD INOCULATIONS. M.J. Wingfield. Department of Plant Pathology, University of Minnesota, St. Paul, MN 55108.

Pathogenicity tests with *Verticicladiella procera* Kendrick and *Leptographium terrebrantis* Barras and Perry were conducted under greenhouse and field conditions. Twenty, two-year-old Eastern white pine (*Pinus strobus*) seedlings were inoculated in the greenhouse with isolates of *V. procera* from the United States, Yugoslavia and New Zealand and an isolate of *L. terrebrantis* to compare the pathogenicity of *V. procera* isolates and reconfirm the pathogenicity of *L. terrebrantis*. *V. procera* did not kill seedlings and caused only localized lesions around inoculation points after five months. Eighteen seedlings died after inoculation with *L. terrebrantis* which appeared to girdle stems and colonize bark before xylary tissues. Root collars of 15-year-old *P. strobus* were also inoculated with isolates of the two fungi. After 12 months, *V. procera* had caused only local lesions. *L. terrebrantis*, however, developed extensively in inoculated trees, producing lesions up to 1.5 m long.

SWISS NEEDLE CAST IN WESTERN MONTANA AND NORTHERN IDAHO

Suzanne H. Dubreuil
Plant Pathologist
Cooperative Forestry and Pest Management
Region 1

Swiss needle cast was first discovered in Montana and Idaho during Christmas tree cutting season in 1981. Since that time, it has been found to be a serious problem in northwestern Montana where millions of wild Douglas-fir are harvested for export to other states and Mexico. It appears the disease, caused by Phaeocryptopus gaumannii, accounts for a condition traditionally called "blight" which has occasionally caused serious losses for Christmas tree harvesters. Most Douglas-fir Christmas trees are harvested by contract on National Forest lands. Region 1 CFPM cooperated with Fortine Ranger District to ascertain the extent of the problem and to seek solutions. Infection levels varied considerably among sampled stands. It was concluded that some losses could be cut by harvesting from less-infected stands. Amounts of postharvest casting were found to correspond well to proportion of needles with sporulation. This may provide a means of selecting stands from which to harvest Christmas trees.

Monitoring Root Disease in North Idaho

by John Schwandt
Idaho Department of Lands

A series of paired photos were displayed showing crown and basal symptoms of individual trees infected with root disease (Armillaria mellea and/or Phellinus weirii). Additional stand information was provided and the viewer was asked how much time had elapsed between photos and also to predict how soon the tree would die.

The photos showed 6 of 112 trees being monitored and represented a range of observations selected to show that after 2 years, there appears to be no close correlation between intensity of symptoms and rate of tree decline or death.

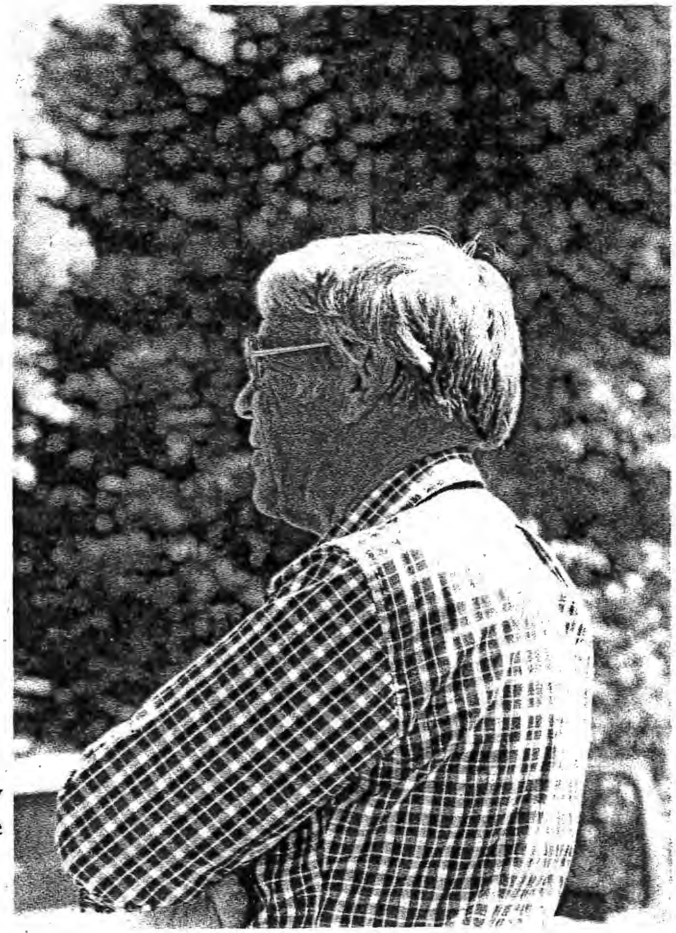
The consensus by those who ventured predictions based on the given information predicted that the tree attacked by bark beetles (but still green) would be dead this fall or early next year. The next two trees were given from 1 to 5 years until death (average 2.2 yr. and 3.0 yr.), while the last tree was given a maximum of 2 years to survive. I will try to provide crown as well as basal pictures of these trees at the next WIFDWC so you can see how your predictions are bearing out.

This study was discussed in more detail at the first stop on the field trip where on-the-ground comparisons were made from photo points of two additional trees. (See field trip discussion for more details.)

ANNUAL RING DETECTION
IN INCREMENT CORES

We have all had difficulty in distinguishing annual rings in increment cores. Now the problem has been solved by some enterprising Dutch scientists who found that visibility of rings is greatly enhanced by dipping the cores in Soy sauce! But not just any brand will do, as "Ketjap Benteng Manis" is best.[1] For some strange reason, the method seems to work best on Far Eastern hardwoods.

F. G. Hawksworth
Rocky Mountain Station



Reference:

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[1]Mention of a trade name or proprietary product does not constitute a guarantee or warrenty of product by the U.S. Department of Agriculture or other governmental agencies or institutions and does not imply its approval to the exclusion of other products that may also be suitable.

Preconference Field Trip

August 18-22

For about fifteen participants, this year's conference began with an "organizational meeting" on Thursday evening August 18 at Oscar and Harriette Dooling's home. Burgers, cold beer and watermelon fueled new arrivals in Missoula in preparation for an early morning departure to the first of several root rot centers to be visited.

At 8:00 Friday morning (give or take...) we loaded into vans to rattle up Marshall Canyon just outside Missoula for close inspection of annosus root rot in ponderosa pine and Douglas-fir and for a breathtaking view of the Missoula Valley.

We then drove to Evaro, north of Missoula, and piled into the Silver Nail Cafe for coffee and to pick up lunches for bagless members of the contingent. With the BIA running interference, we dodged logging trucks to the top of the Finley Unit overlooking Evaro valley. Here, Ken Dupuis, chief forester for BIA in Ronan, Rolan Becker, timber stand improvement forester, and Sue Dubreuil, discussed a demonstration of root disease control methods on a 3,000-acre tract of the Flathead Indian Reservation. The project, prepared jointly by BIA and Region 1 CFPM, will serve for training and demonstration of effects of various silvicultural practices on Armillaria root disease situations in western Montana.

Aerial photographs taken before stands were treated provided background information on status of stands to compare with current conditions as we toured various treatments.

Lunch was consumed amid the stumps and slash of a recent clearcut which provided a lovely view of the Evaro valley. Once the Colorado contingent rejoined us after a short tour of their own, we quickly hiked off lunch, consumed a few late huckleberries and proceeded to Polson's Queen's Court Resort on the southern tip of Flathead Lake.

The group stopped at the Coram Experimental Forest (Flathead National Forest) on Saturday morning to examine mature Douglas-fir which were being attacked by Douglas-fir bark beetle. Groups of recently killed trees had extensive root infection by Phaeolus schweinitzii. Bark beetles were apparently attacking trees severely weakened by the root disease. The group examined several excavated lateral roots which had characteristic reddish discoloration indicative of infection by P. schweinitzii Relative occurrence, host range, and importance of P. schweinitzii in the Northern Region were discussed.

On Saturday afternoon, the group visited Glacier National Park. Stops included Lake McDonald, McDonald Creek, and Logan Pass. Fire ecology along the Going-to-the-Sun Highway was discussed as well as progression of the recent mountain pine beetle epidemic on lodgepole pine within the Park. Several minor diseases were examined, the most notable being Lophodermella concolor on lodgepole pine. Occurrence of root diseases and their management in campgrounds and other areas of concentrated public use were discussed.

On Sunday, the group visited McGregor Lake Campground (Kootenai National Forest) where all trees within the campground had been removed to "control" mountain pine beetle. History of the project and role of Forest Pest Management was discussed. Recommendations had been made to protect valuable campground trees from beetle attacks with a chemical spray (Sevin®). However, the Forest Supervisor decided that the environmental impacts from chemical spraying were not justified. Therefore, susceptible trees were removed instead of being sprayed. The campground is now without any tree cover and use has greatly declined.

The Blue Fat timber sale area on the Cabinet Ranger District (Kootenai National Forest) was also visited on Sunday. Several large root disease centers, caused by Phellinus weirii, were seen. Problems caused by this disease in northern Idaho and northwestern Montana were discussed. The area visited had several constraints such as wildlife habitat and viewing from a nearby highway. How such constraints can be integrated into silvicultural prescriptions that are designed to reduce root disease losses was discussed.

On Monday morning a group of 12 enthusiastic pathologists (and a couple of token entomologists) left the North Shore Lodge for Bonners Ferry.

After stopping in Sandpoint to pick up the root disease tour group (aand a few liquid lunch supplies), we headed for Bonners Ferry and the Clifty View Nursery which is nestled at the base of the mountains in Paradise Valley.

Lon Merrifield has turned his old family homestead into a commercial nursery with about 80 acres planted to over 200 different kinds of trees and shrubs. He has contracts with many area timber companies as well as the State of Idaho to grow most of our commercial timber species. He is also the primary local source for Christmas tree stock and ornamental hardwoods. Over the past 3 years he has experienced some severe losses from Sirococcus tip blight on his ponderosa pine. He now feels he has controlled his problem but it takes almost weekly sprays with chlorothalonil to do it. Lon also had samples of several other minor problems which he used as a field quiz to see if our collective mass of knowledge could agree on any answers.

After an enjoyable picnic lunch at the Bonners Ferry City Park, we headed to J. Hoffert's Christmas tree plantation near Elmira, Idaho. This region has several hundred acres of Christmas tree plantations planted almost exclusively to Scotch pine and J. Hoffert is one of the largest local producers. Gary Cartisano, the local manager, led the tour through the plantation and explained his disease problems to the group. Of particular concern is the threat of Lophodermium needle cast which nearly wiped out a small plantation near Sandpoint when it was first discovered in our area a couple of years ago. He was also concerned about a needle problem on grand fir which stumped the entire group. Gary also had the (forced) opportunity to explain (justify) to Harriette Dooling why trees were sheared so tightly and painted green prior to shipping.

The group then headed for Coeur d'Alene and the hospitality room to prepare for the conference in earnest.

FIELD TRIP NOTES
August 25

Summary[1]

Root rot, white pine blister rust, and western gall rust were revisited under the sunny skies as an estimated 70 WIFDWC participants took to the woods. We first examined a stand in Cougar Gulch where John Schwandt has been monitoring symptom progression in several trees infected with a variety of root rots (*Armillaria mellea*, *Phellinus weirii*, and *Phaeolus schweinitzii*). Photographs were displayed at permanent photo points to compare tree crown conditions with the photos which were taken 1 and 2 years ago. The setting also provided an opportunity for Geral McDonald and Neil Martin to discuss some recent developments in their studies of *Armillaria*. Rhizomorphs on several trees (including a maple) were excavated. A lively discussion ensued (something to do with the sexual activities and mating habits of the native *A. mellea*).

A commercially thinned stand which has developed into a prime firewood gathering area in the Pleasant Creek area southwest of Coeur d'Alene, was presented by Jerry Sheldon, silviculturist on the local Fernan Ranger District. Jerry, and Sue Rainville, also a Fernan district silviculturist, discussed the problem of root disease mortality following partial harvesting of stands. Pleasant Creek stands provided impressive examples of the seriousness of the situation. *Phellinus weirii* was the major problem in the stand examined, but *Armillaria mellea* was prevalent in other stands seen along the way.

We picnicked in the Idaho fescue and quenched thirsts with beer and pop cooled in a horse trough. After lunch, Geral entertained the group with a discussion of his white pine blister rust hazard rating system. It aids in selecting resistance levels of white pine planting stock for various sites. White pine is considered by Northern Region pathologists to be an important alternative species to root disease-riddled Douglas-fir and true firs in the Idaho Panhandle National Forests.

As a bonus in Pleasant Creek area, we were able to observe the similarity of severe larch sawfly defoliation to larch needle diseases. Larch dwarf mistletoe collections also were made.

Lone Mountain Tree Improvement area was the site of our wrap-up. Ray Hoff explained his research will gall rust and needle cast in lodgepole pine. Both diseases were visibly more severe in some families than in others. These are the most common diseases of lodgepole pine in the Northern Region as was seen by the heavy natural infections in Ray's study trees.

The excursion ended with a stroll through the ribes garden at Lone Mountain. Here, white pine blister rust inoculum for progeny testing is produced.

The entire WIFDWC crew then descended on the Schwandt's home for volleyball, croquet, and bountiful cuisine extraordinaire provided by Donna and John. The perfect end to a perfect day.

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[1]See discussions of trip topics following this summary.

MONITORING ROOT DISEASES IN NORTHERN IDAHO

by

John Schwandt

Introduction

During the summer of 1981, a total of 112 permanent plots were established to monitor root disease activity in 17 root disease centers in six timber stands in northern Idaho. We were especially interested in monitoring the progression of crown and basal symptoms leading up to the death. The following is a summary of the root disease activity in these areas at 1 to 2 years of observation.

Methods

Field procedures and data collection involve the establishment of permanent 1/20-acre timber cruises and 1/50-acre regeneration surveys centered on trees exhibiting some degree of the root disease symptoms. (Refer to IDL Report 81-8 for details.

Trees selected for observation were generally near the margins of root disease areas in order to include as many live trees as possible so that the root disease activity could also be monitored in nearby nonsymptomatic trees. Permanent photo points were established for each tree to provide a photographic record of symptom progression.

Results

After approximately 1 year, 30 percent (34 trees) of the original 112 trees have died and another 22 percent (25 trees) exhibited more advanced symptoms. Three of the dead trees had fallen over revealing totally decayed root systems.

All of the dead and symptomatic trees were grand fir or Douglas-fir. About 60 percent (20 of 34) of the dead trees were infected with *Phellinus weirii* while 35 percent (12 of 34) had *Armillaria mellea* and two trees had both root disease fungi. In addition, bark beetles or wood borers were found in nearly one-third (11 of 34) of the dead trees while the rusty brown stain spots were observed on 40 percent.

In most cases the 1/20-acre cruises tallied more dead and dying trees than healthy trees. The percentage of dead trees tallied during these cruises in the six areas varied from a low of 30 percent to 60 percent in the field trip area. The remaining live trees frequently exhibited some root disease symptoms. Most of the 1/20-acre cruises tallied 20-40 percent of all live trees as declining or in fair condition. The percentage of residual trees with symptoms varied from 75 percent to about 10 percent in an area where salvage logging had recently removed most symptomatic trees. Over the past year, 23 trees in the 1/20-acre plots had also died and 33 others exhibited more intensive symptoms.

At this point, there appears to be little correlation between the intensity of crown or basal symptoms and tree death. Some trees with very poor crowns have not changed appreciatively over the past 2 years while a few trees with relatively good crowns died and fell over during the same period.

Although most trees exhibit crown and some level of basal symptoms prior to death, no apparent pattern can be established after 2 years of monitoring. Both *A. mellea* and *P. weirii* produce similar symptoms although *A. mellea* appears to create more basal pitching on infected trees.

Field Trip Notes

Each tree has a series of colored rings painted around it to represent its condition each year starting with 1981 at the top. The color codes are as follows:

Yellow = crown symptoms present
Orange = basal symptoms present (basal pitch and/or rusty color)
Yellow/Orange = both crown and basal symptoms present
Red = dead.

ROOT DISEASE IN THE PLEASANT CREEK TIMBER SALE AREA

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IDAHO PANHANDLE NATIONAL FORESTS

INTRODUCTION

Root disease is likely to be the most serious long-term pest management problem on the Idaho Panhandle National Forests (James and Tunnock, 1981). Phellinus weirii, Armillaria mellea, Phaeolus schweinitzii, Fomes annosus and Ceratocystis wageneri are all present. However, P. weirii and A. mellea are probably the most serious root pathogens with A. mellea being the most widely spread but P. weirii causing the greatest concentrations of mortality in the areas where it is present.

P. weirii can be found over much of the Idaho Panhandle National Forests but the greatest concentrations of this pathogen are in the vicinity of Coeur d'Alene, Idaho, which includes the Fernan Ranger District. On the Fernan District, P. weirii is most pronounced in areas below approximately 4500 feet that were burned over by a large replacement wildfire in the 1880's, and are currently 80 to 100 year old stands dominated by grand fir (Abies grandis) and Douglas-fir (Pseudotsuga menziesii). This is an area of approximately 100,000 acres or one third of the entire District. The Pleasant Creek Timber Sale lies within this area.

The full extent of the area being impacted by P. weirii on the Fernan District may be greater, but its presence could be partially masked by the presence of older stands where much of the grand fir and Douglas-fir component has dropped out and stands that have regenerated to a broader mix of species. The presence of P. weirii mortality in sapling size grand fir and Douglas-fir in some regenerated clearcuts would tend to indicate that this may be the case.

DISCUSSION

The Pleasant Creek Timber Sale was sold in 1976. At the time of the sale, timber stands averaged 80 years old and were generally healthy and growing well. The presence of root disease (primarily P. weirii) was known but it was thought that a commercial thinning would help to reduce stress, thereby improving the ability of the residual stand to compete and thus reducing loss to all pests, including root disease. As a result of this sale, approximately 1000 acres have been commercially thinned by leaving the largest, healthiest trees on a 25 x 25 foot spacing.

Most of the logging was done in 1978 with much of it occurring in the winter over the snow. This resulted in minimal logging damage to the residual stand. However, mortality was occurring in the residual grand fir and Douglas-fir as a result of root disease. An effort was made during logging to replace leave trees that had died since marking with other healthy trees in an effort to maintain the desired stocking level. Wallis (1976) reports that probably less than half of the P. weirii infected trees in a stand can be recognized from above ground symptoms. Within the Pleasant Creek Timber Sale, numerous trees that had no obvious crown symptoms in 1976 had died by as early as 1978 and other trees are still dying in 1983. A survey of the sale completed in 1983 shows that 11% of the designated leave trees have died since 1976, and another 3% have advanced crown symptoms that would indicate death within the next one to two years. This mortality has been limited almost exclusively to grand fir and Douglas-fir. In addition, mortality is not limited to isolated root disease centers but also includes a large amount of individual tree mortality spread throughout the entire sale area. There has been little if any mortality in western larch, ponderosa pine or western white pine within the sale area that is attributable to root disease, during this same time period.

Partridge, et al. (1978) has indicated that thinning seems to favor the spread of P. weirii root disease. Without accurate mortality data prior to logging, it is difficult to say precisely what effect logging has had on root disease mortality rates. However, it is evident that harvesting by a commercial thinning that attempted to leave only the healthiest trees has not reduced mortality rates in Pleasant Creek. The general opinion is that, if anything, mortality rates have increased since logging.

The original prescription for this area called for the commercial thinning to be followed by a shelterwood cut, site preparation and regeneration in approximately 20 years. As early as 1981 it was evident that residual stocking was well below that desired for a commercial thinning and stocking was continuing to decrease as a result of ongoing root disease mortality. These open, but still partially shaded, stand conditions coupled with limited mineral soil exposure following logging were producing ideal conditions for the establishment of grand fir and Douglas-fir seedlings. It was felt that if this situation was allowed to continue, a dense understory of root disease susceptible grand fir and Douglas-fir would exist well before the proposed shelterwood cut in 20 years. Therefore, the decision was made in 1981 to underplant western larch, western white pine, ponderosa pine and cedar in all the areas of Pleasant Creek that had originally been marked as commercial thinnings. This planting will be completed during the fall of 1983. Future management plans now call for removal of the residual overstory in the next 5 to 10 years followed by precommercial thinning in about 15 years that will be directed towards favoring species other than grand fir and Douglas-fir. This change in plans can be directly attributed to the extremely high rates of root disease mortality that occurred after logging within the sale area.

SUMMARY

As a result of the Pleasant Creek Timber Sale, personnel on the Fernan District have become much more aware of the presence of, and the problems associated with, timber management in areas of P. weirii root disease. Based on our experiences, we can offer the following observations and recommendations.

1. The use of above ground tree condition is not a reliable method of identifying those trees that might survive for the next 5 to 10 years. Trees with no obvious crown or bole symptoms have been observed to die within 2 to 3 years.

2. Mortality rates are significantly lower in western larch, ponderosa pine, western white pine, lodgepole pine, cedar and western hemlock even when growing in close association with actively dying grand fir and Douglas-fir.

3. Mortality rates are unabated by partial cutting and if anything increase after logging. Intermediate cuts should be limited to removing dead and highly symptomatic trees or else avoided completely until the stand can be regenerated in a manner that will favor the establishment of species other than grand fir and Douglas-fir. Attempts at commercial thinning are not worthwhile unless most of the grand fir and Douglas-fir can be removed from the stand.

4. Grand fir and Douglas-fir regenerate prolifically in areas of heavy P. weirii activity and appear healthy and grow well right up until the year they die of root disease. This can be very deceptive, often giving the appearance of healthier stand conditions than actually exist.

Therefore, care must be taken when prescribing overstory removals in areas where root disease is active to avoid releasing stands dominated by grand fir and Douglas-fir that may not be capable of carrying stocked conditions through to the next rotation.

5. Extreme care should also be exercised before prescribing uneven-aged management on the grand fir/pachistima habitat type in northern Idaho. This silvicultural system will strongly favor grand fir and Douglas-fir on this habitat type, thereby perpetuating and enhancing the development of any root disease complex that might be present.

LITERATURE CITED

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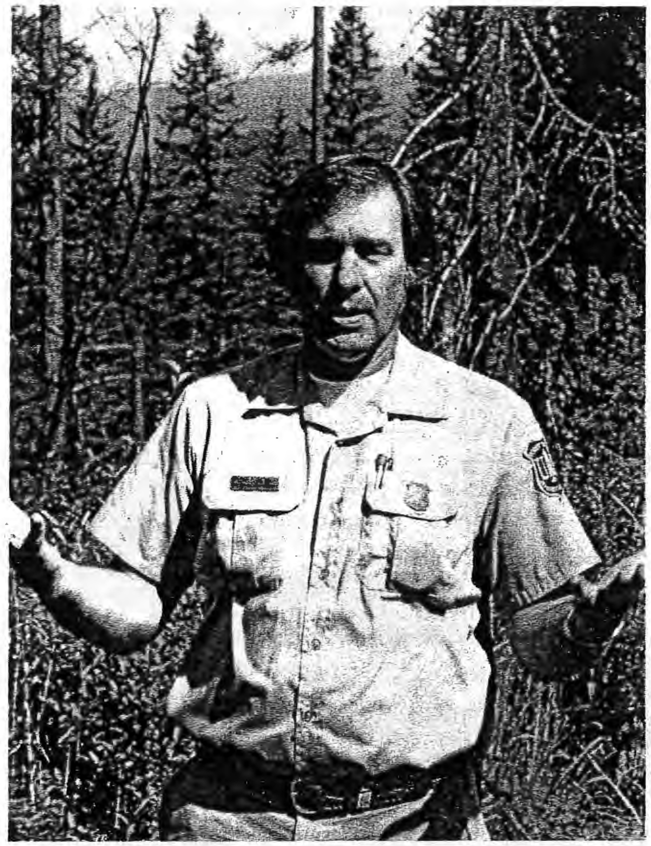
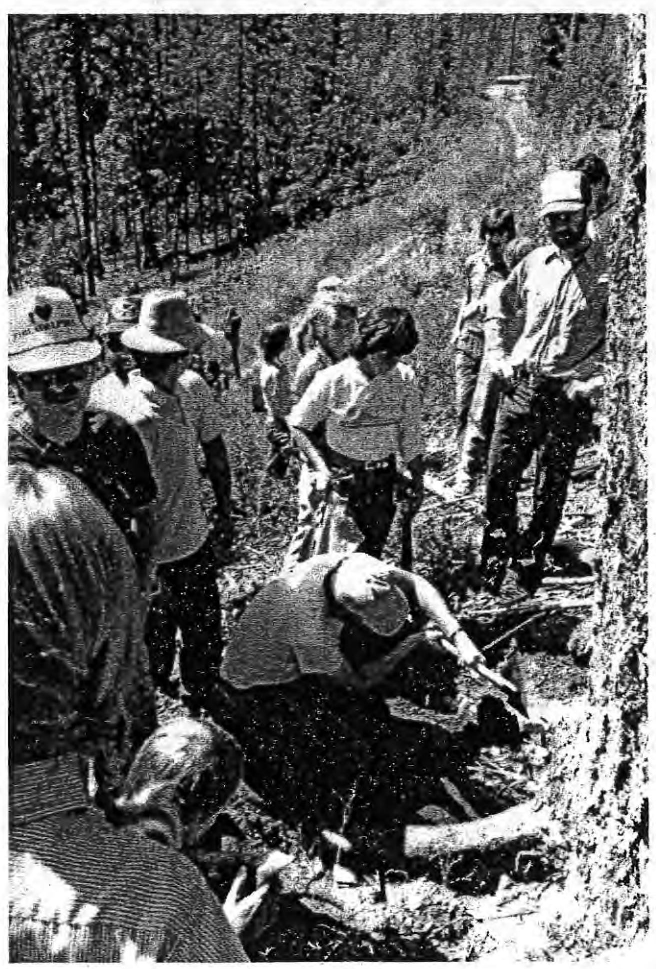
Partridge, A.D., E.R. Canfield and D.L. Kulhavy. 1978. Keys to Major Disease, Insect and Related Problems of Forests in northern Idaho. Forest, Wildlife and Range Exp. Station, No. 127, University of Idaho, Moscow, ID.

Wallis, G.W. 1976. Phellinus weirii Detection and Management Proposals in Douglas-fir Stands. Forestry Tech. Report 12, Canadian Forest Service, Department of the Environment, Victoria, B.C.

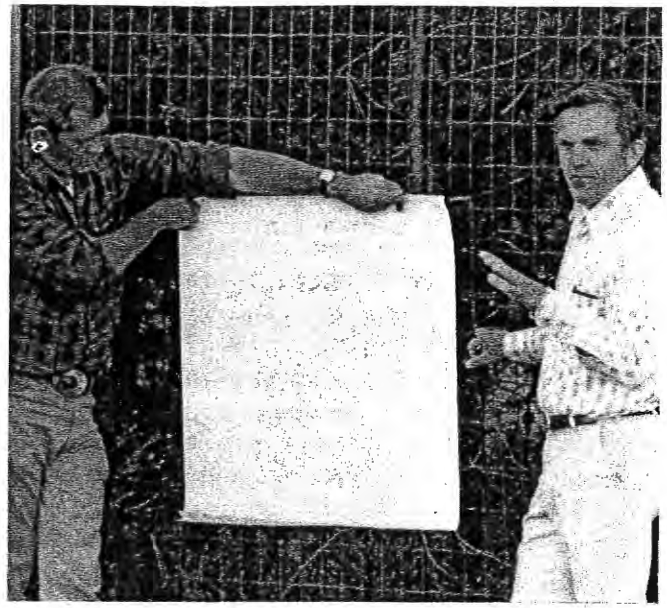


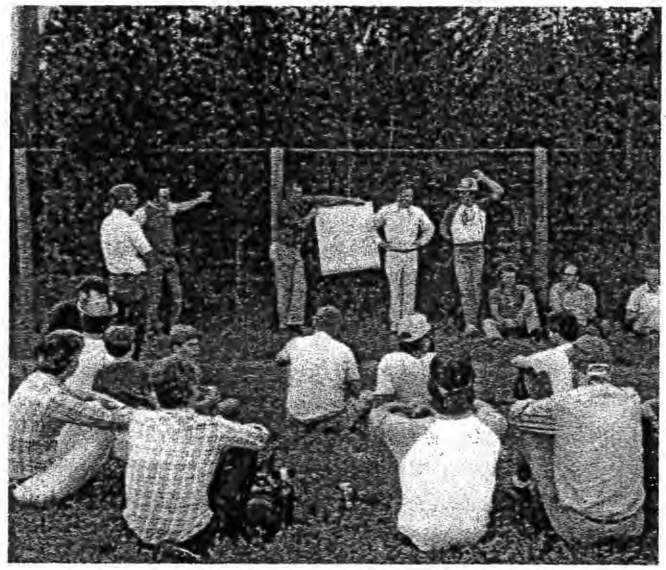


WESTERN GALL RUST AND NEEDLE CAST ON LODGEPOLE PINE AT THE LONE MOUNTAIN TREE IMPROVEMENT SITE

by

R. J. Hoff





One-year-old, container-grown lodgepole pine seedlings from 193 families representing 21 northern Idaho stands were planted at Lone Mountain in spring 1980. There are 5 blocks with 8 seedlings per family per block, planted as single-tree plots. Gall rust was first evident in fall 1980, and data was taken in fall of 1981 and 1982. The average infection after the 1982 inspection was 13%, ranging from 8% to 17% for stands and 0 to 36% for families. Differences among stands and families were significant at 1% level of probability.

Needle cast (caused by Lophodermella concolor) infection appeared to be quite uniform throughout the plantation in June 1983. Data was taken June 13 - 15 as follows: 0 = no infected needles; 1 = 1 - 5% infection; 2 = 6 - 35% infection; 3 = 36 - 69% infection; and 4 = 70 - 100% infection. The average percentage of infected 1982 needles was 29%, ranging from 9 - 44% for stands and 1 - 56% for families. Differences for stands and families within stands were highly significant. Heritability based on individuals was 24%. The correlation coefficient of infection or elevation was 0.8.

The business meeting was called to order by Chairman John Laut at 10:30 a.m. August 26. Pertinent information is summarized here (numerous extrapertinent activities also transpired in the course of the business meeting).

Reports

Mistletoe Committee--Meeting was held over lunch on Tuesday, August 23 with 25 in attendance. Chairman John Laut has supplied notes which are presented on pages 90 - 95 of these Proceedings.

Root Disease Committee--Meeting was held over lunch on Tuesday, August 23 with 31 in attendance. Chairman Greg Filip has provided a summary which appears on pages 96 - 97.

Disease Control Committee--No formal meeting of this committee was held this year. Ken Russell, Chairman, was attending the Phytopathology meetings in Australia at the time of WIFDWC. A summary of the committee report will appear in the 1984 Proceedings.

Interim program--Chairman Jack Marshall called for additional suggestions for next year's program (having received none at the time of the business meeting). He subsequently supplied the report presented on page 98.

Treasurer's report--John Schwandt, Local Arrangements Chairman, presented a tentative report of conference receipts and expenses at this meeting. The final Treasurer's report appears on page 99. Ken Russell, who maintains the deposit for us at the Washington State Employees Credit Union, has explored the possibilities for investing the funds in a money market certificate and found it to be impractical. The funds will remain in a savings account at the credit union where they earn about 6.5 percent interest.

Old Business

Last year's business meeting minutes were read and approved as written in the Proceedings of the 30th Conference.

Charge to Students for Proceedings

Cost of Proceedings was discussed again this year. John Schwandt reminded us of a decision, written in the 10th Proceedings, to charge students only 50 percent of cost to other members (excluding life members). Rich Hunt suggestted that the fees for Proceedings and other conference costs often are not of sufficiently clear origin to assign a percentage charge for student members. No new policy was established. Most agreed that students should pay less, but that amounts will apparently be set annually by the current Secretary-Treasurer.

Common names

Frank Hawksworth and Bob Gilbertson presented a list of common names for western forest diseases as was requested in the business meeting 1982. Copies of the list were distributed among the membership and all were asked to make comments and return them to Frank or Bob as soon as possible. A final list will be prepared following consideration of comments received. Publication of the list will be announced at the 1984 WIFDWC.

Meeting location

Ed Wood suggested alternating between urban and rural settings for WIFDWC meetings.

Ed described the location and facilities of the 1984 meeting in Taos, NM. He described the lodge as having a 'Pingree Parkish" setting. The tentative week is the last in September wher the Feast of San Jeronomo takes place. Ed suggested a 3-day pre-WIFDWC historic tour of New Mecixo, a conference tennis tournament, and a tour of Taos. Air travelers will be shuttled from Albuquerque.

New Business

Nominations for a 1985 conference location were received from Bob Edmonds and Ed Wood. Bob proposed Olympia, Washington as it is "only 2 days' drive from Taos." He also stressed that the time is ripe for a Mount St. Helens tour.

Ed Wood nominated Bend, Oregon on behalf of R-6 FPM group who were not present but who traditionally offer the location.

Nominations were closed and the Olympia location was selected by a clear majority.

Gordie Wallace's retirement from the post of WIFDWC Historian was read to the membership by Rich Hunt. Gordie recommended Duncan Morrison to succeed him. The membership asked that a letter expressing our gratitude to Gordie be drafted by John Laut. It was unanimously agreed that Duncan Morrison be asked to assume the position of Historian.

Rich also read a motion offered by Gordie that $50 be appropriated from the WIFDWC treasury to have volumes 15-30 of the Proceedings bound. The motion was carried.

The nomination committee of Oscar Dooling, Bob Scharpf, and Bob Gilbertson presented Tommy Hinds for Chairman and Rich Hunt for Secretary-Treasurer of the 1984 WIFDWC. Nominations were closed and Tommy and Rich were unanimously voted into office. (Tommy has appointed Jim Byler to serve as 1984 program chairman.)

Western International Forest Disease Work Conference
Mistletoe Committee Report
1983 Highlights

John G. Laut, Chairman

I. Taxonomy, Hosts and Distribution

A. International developments on the dwarf mistletoe front. A new species, Arceuthobium tibetense, on Abies was described from Yunnan Province, in southwestern China (Kiu, H-X, Wei, R., A new species of Arceuthobium from Xizang. J. Yunnan For. Collect No. 1, p. 42-45, 1982). Also Arceuthobium (presumably A. bicarinatum on Pinus occidentalis) has been reported for the first time in Cuba (Leiva, A. T., un neuvo genero de Loranthaceae para la flora de Cuba: Arceuthobium. Revista Jard. Bot. Nac. 4(2), 1983). F. G. Hawksworth, RM Station.

B. The dwarf mistletoes have been a source of taxonomic confusion owing to their reduced morphology, high degree of sympatry, and host relationships. Although others have experienced difficulty in resolving enzyme systems in dwarf mistletoes using horizontal starch gel electrophoresis, seeds of A. vaginatum spp. crytopodum give excellent banding at the 6-phosphogluconate dehydrogenase locus. Megasporogenesis in Arceuthobium conforms to the Allium type and the resultant endosperm is triploid. The gel banding patterns derived from the endosperm tissue confirms the triploid condition since all heterozygotes for this dimeric protein are asymetrical. The dosage effect is exerted by the triple fusion phenomenon of endosperm cell nuclei production. The paternal chromosome contribution is one and the maternal contribution two. Genetic data derived from this type of analysis is being used to examine (1) the biosystematics of 22 taxa in the genus Arceuthobium, (2) population dynamics, and (3) the concept that niche width (the number of hosts colonized) may be correlated with the degree of heterozygosity for a particular taxon. (Dan Nickrent, Miami Univ., Oxford, Ohio.)

II. Physiology and Anatomy

No report.

III. Life Cycle Studies

A. Establishment of Arceuthobium americanum beyond the normal range of seed expelled from explosive fruits indicates involvement of vectors. A study on the Fraser Experimental Forest in Colorado identified eight bird and three mammal species as potential vectors. In all, 320 birds (including retraps = IRT) of 29 species, and 375 mammals (IRT) of 4 species were trapped and examined. Seven percent of the birds and 14 percent of the mammals carried seed. During a 16-day peak seed-dispersal period at one site, 32 percent of the birds (N = 25 IRT) and 23 percent of the mammals (N = 99 IRT) carried seeds. Important vectors appear to be the least chipmunk (Eutamias minimus), gray jay (Perisoreus canadensis), Steller's jay (Cyanocitta stelleri), and Audubon's warbler (Dendroica auduboni). These studies are being followed up in 1983 by continued trapping of potential vectors and radio tracking of bird vectors. (Tom Nicholls, NC Station, F. G. Hawksworth and Laura Merrill, RM Station.).

B. The manuscript "Population dynamics of dwarf mistletoes in young true firs in the Central Sierra Nevada" has finally been printed as PSW Research Paper 161, 1982 after a 2-year delay because of USDA moratorium on publishing. (R. F. Scharpf, PSW; J. R. Parmeter, Jr. U.C.).

IV. Host-Parasite Relations

A. Completed field measurements 13 years after establishment in a spread and intensification study in Douglas-fir in western Montana. Results are not available; data will be analyzed this winter. We will decide then if the study will be continued another 5 years. (O. J. Dooling, CFPM, Region 1).

V. Effects on Hosts

A. A computer-based simulation model for mistletoe-infested, mixed-conifer stands in Arizona and New Mexico is nearly completed. The model will have the capability of predicting yields in uninfested stands and those infested by various combinations of A. douglasii, A. micracarpum, and A. vaginatum, (R. L. Mathiasen, Northern Arizona University; C. B. Edminster, and Frank G. Hawksworth, RM Station; E. Wood, FPM, Region 3).

B. A new study is underway to develop dwarf mistletoe loss and intensification equations for a growth and yield model for uneven-aged ponderosa pine stands in Colorado and the Southwest that are being developed by E. B. Edminster of the RM Station. The evaluation will be based on data from established, long-term and temporary plots, Stage II inventories, and new plot data as needed. (H. Maffei and B. Jacobi, Colorado State University; and F. G. Hawksworth, RM Station).

C. As a continuing effort to evaluate the effects of dwarf mistletoe in managed lodgepole pine and ponderosa pine stands, nine new plots in thinned lodgpeole pine were established in Colorado. Also, 5-year examinations of 24 plots in ponderosa pine in Arizona were made this summer. In all, we are monitoring the effects of dwarf mistletoe in 139 thinned plots, 89 in ponderosa pine and 50 in lodgepole pine (F. G. Hawksworth, T. E. Hinds, and Laura Merrill, RM Station).

D. The manuscript "Stem infection of dwarf mistletoe in California firs", also delayed by the USDA moratorium, is in print as PSW Research Paper 165, 1982 (R. F. Scharpf, PSW).

VI. Ecology

A. The relationship of ponderosa pine dwarf mistletoe with habitat types and other ecological factors has been studied in Colorado. This investigation assesses the relationship between forest habitat types, other ecological factors (slope, aspect, elevation, topography, configuration, site index, and basal area) and the frequency and severity of ponderosa pine dwarf mistletoe (Arceuthobium vaginatum subsp. cryptopodum) in Colorado. Data on 547 variable-radius plots (171 infested with dwarf mistletoe were accumulated throughout the Roosevelt, Pike, and San Juan National Forests in Colorado. A total of eight habitat types and one unknown category were recognized. Results from this study suggest that A. vaginatum occurs most frequently and is most severe on the driest ponderosa pine sites, typically supported by the Muhlenbergia montana habitat type. This habitat type, occupying some of the most xeric environments associated with ponderosa pine series, is shown to harbor significantly more dwarf mistletoe than the average condition observed for the remaining habitat types, and maintain a significantly higher dwarf mistletoe rating than five of the habitat types and one unknown category (Laura Merrill and F. G. Hawksworth, RM Station; and W. R. Jacobi, CSU).

VII. Control-Chemical

A. Chemical control tests on Arceuthobium vaginatum on ponderosa pine near Estes Park, Colorado were continued. Some 14 herbicides were tested in nearly 400 dwarf mistletoe plants. Various combinations of dosages and treatment methods (sprays, bark slits, and mauget capsules) were tried. The four chemicals that had the most effect on the parasite and least damage to the host trees were (1) Rhone Poulene (2,4-D), (2) Dow D-40 (Ethanug isopropanol salt of 2,4-D), (3) Upjohn Actiaid (cycloheximide plus surfactant), and (4) Rhone Poulene MCPA (2-methyl, 4-chlorophenory acetic acid). Sprays were most effective; application of chemicals through bark slits or capsules gave inconsistent results. Although the best chemicals give consistent kill of aerial shoots, the long-term effects on the mistletoe endophytic system are uncertain. Tests are continuing (A. Moinat, P. O. Box 2446, Estes Park, Colorado).

B. The plant growth regulator, floral, is effective in stimulation abscission of A. pusillum shoots in black spruce (Livingston and Brenner, 1982 WIFDWC Proc., p. 104-107, 1983). This ethylene releasing agent will be tested on A. americanum and A. vainatum in Colorado this summer (T. H. Nicholls, NC Station; and F. G. Hawksworth, RM Station).

VIII. Control-Biological

A. The rust fungus, Peridermium bethelii, which is associated with dwarf mistletoe (Arceuthobium americanum) in lodgepole pine (Pinus contorta), has generally been considered synonymous with Cronartium comandrae. P. bethelii, however, differs in its smaller, less pyriform aeciospores, apparent lack of spermagonia, later aecial sporulation period, and constant association with dwarf mistletoe. Attempts to infect mistletoe-infected pines were either unsuccessful or inconclusive and potential alternate hosts have not been found. Field evidence suggests the rust may be autoecious. The rust occurs in Colorado, Wyoming, Utah, Montana, Idaho, and California (published in Plant Disease, 1983) (F. G. Hawksworth, C. Dixon, and R. G. Krebill, USDA Forest Service, RM and INT Stations).

IX. Control-Silvicultural

A. A manuscript is in preparation on 7 years of work on "The effect of pruning dwarf mistletoe brooms on Jeffrey pines on tree growth and longevity." Results compare the intensity of dwarf mistletoe before and after pruning, number of brooms removed, and live crown ratio before and after pruning to growth and survival of treated and untreated pines. The tests were conducted on the Cleveland National Forest in Southern California and results will apply mainly to high-use recreational forests (R. F. Scharpf, PSW; D. Vogler and R. S. Smith, Region 5).

B. Dwarf Mistletoe Control. A sanitation cutting of lodgepole pine infested with dwarf mistletoe was undertaken on 50 hectares in the Invermere District (E. Morris, Nelson Forest Region, Nelson, B. C.).

C. Treatment of Pests and Residual Stems in Lodgepole Pine Type Cutblocks. In a combined effort, Silviculture and Protection Staff formulated regional guidelines to deal with lodgepole pine residuals in cutblocks. The residual stems and patches tend to act as infestation centers for a wide variety of insects, diseases, and rodents, which then spread into natural regeneration as well as physically inhibiting the establishment of new stands. Application of the regional guideline is intended to reduce pest losses and encourage the establishment of healthy natural or planted regeneration on lodgepole pine cutblocks. The guideline will apply to current harvesting (T. Wilford, Cariboo Forest Region, Williams Lake, B.C.).

D. Demonstration Areas. A demonstration area of mistletoe control options at time of logging or juvenile spacing was established in the Palmer Lake area in the Cariboo Region. Further demonstrations of operational methods to control dwarf mistletoes are planned for 1983-84. Proposed activities include selection of suitable areas for mistletoe control in Cariboo, Kamloops, Prince Rupert and Nelson Regions. Establishment of demonstrations might be possible under EPAP or NEED Programs (J. A. Muir, Protection Branch, Victoria, T. Wilford, Cariboo Forest Region, Williams Lake, B.C.).

E. Dwarf Mistletoe Control Projects. A number of cutblocks were treated via several EBAP and NEED Programs. Several companies used Section 88 funds and harvesting techniques to reduce the occurrence of the parasite (T. Wilford, Cariboo Forest Region, Williams Lake, B.C.).

F. Guidelines. Revised dwarf mistletoe guidelines were redistributed for comment. These should be finalized by September 1983 (J. Muir, Protection Branch, Victoria, B.C.).

G. Lillooet Mistletoe Control Projects. A large flat area (1,800+ ha) in the Lillooet Forest District contains heavily mistletoe-infested timber. Stand growth has virtually stagnated and some of the older stems are dying. Mountain pine beetle is also attacking some of the older stems. To date, three forest management projects have been used to eradicate the mistletoe. For the larger stems, a Small Business Sale (Category 2) was issued on approximately 80 ha with some success. A post and rail sale has also been issued with little success. Recently

$30,000 was spent on a mistletoe trial control project. This project will be carefully monitored to determine the feasibility of treating more areas. Six blocks, for a total of 60 ha, were treated and costs ranged from $300/ha to $600/ha depending on ground conditions and the actual treatment. Most of the 60 ha were windrowed or rough bunched to prepare the site for burning in the fall. The cheapest treatment area was prepared for broadcast burning. A 50-meter-wide firebreak was made to encircle the block and the remaining material was flattened to ground level. A D8K was used to prepare the blocks in conjunction with a labourer who felled any remaining live stems. An LKS was issued to a local operator to utilize any merchantable stems. When the project is completed, no live stems will be left standing except the odd Douglas-fir. Followup action will include burning of all slash accumulations this fall and planting of lodgepole pine and Douglas-fir stock during the spring of 1984. Grass seeding will also take place in a number of blocks (E. Holley, Lillooet Forest District, Lillooet, B.C.).

H. Pathology and Silviculture Project. A silviculture project in the Kamloops District was undertaken to control mistletoe. On 235 ha, crews removed mistletoe-infested residual stems left after old-diameter limit logging. This project was funded by the Employment Bridging Assistance Program, (J. B. Olsen, Kamloops Forest District, Kamloops, B.C.).

I. Lodgepole Pine Dwarf Mistletoe Prespacing Examination. A prespacing examination of dense lodgepole pine stands for pests in the Hawkins-Freeman drainages in the Kootenay Lake District indicated little or no mistletoe infestations. However, reexamination during the actual thinning process indicated a significant amount of dwarf mistletoe. Because of stand density, lodgepole pine stems gave almost no visual signs, i.e., abnormal growth or basal swellings with aerial shoots. Examination of felled trees revealed mistletoe aerial shoots on the majority of trees. Most field surveys used at present to detect the presence and extent of dwarf mistletoe infections would fail in stands of this type unless a great deal of time was spent examining individual trees with binoculars. These types of stands are quite common in the Nelson Region (E. Morris, Nelson Forest Region, Nelson, B.C.).

J. Mistletoe Appraisal Technique. John Laut, Forest Pathologist under contract with Protection Branch, will complete evaluation of a mistletoe appraisal technique, LPMIST, for management of interior lodgepole pine stands. Results of preliminary 1982 tests suggested that LPMIST might overestimate stand growth and perhaps should be adjusted (J. A. Muir, Protection Branch, Victoria, B.C.).

K. Plans are to treat 7,750 acres of *A. americanum*-infested lodgepole pine stands on the Arapaho and Roosevelt, Grand Mesa, Uncompahgre and Gunnison, Medicine Bow, Pike and San Isabel, Routt, Shosone, and White River National Forests. The majority of this work will be accomplished with the Jobs Bill Program (D. W. Johnson, USDA Forest Service, Region 2).

L. Overstory removal and thinning/sanitation were accomplished on about 2,000 acres on the Bitterroot, Flathead, Kootenai and Lolo National Forests; and on BIA and BLM lands in Montana (O. J. Dooling, CFPM, Region 1).

M. Treated 1,451 acres of *A. americanum*- or *A. douglasii*-infested stands on southern Idaho forests (J. Hoffman, USDA Forest Service, Region 4).

N. Two programs have been developed for programable calculators that predict the effects of dwarf mistletoe on unmanaged lodgepole pine stands in central Oregon. LPDMVOL will predict yields for any specified time period. LPDMECO performs a present net value analysis of immediate clearcutting versus carrying the stand longer. Both programs can be run with stand examination data already being collected by foresters (Craig Schmitt, FPM, Region 6).

O. Treated 408 acres of *A. americanum*-infested lodgepole pine stands on the Ashley, Bridger-Teton, and Wasatch

National Forests. Treated 500 acres of A. vaginatum-infested ponderosa pine stands on the Dixie National Forest. Treated 423 acres of A. campylopodom-infested ponderosa and Jeffrey pine stands on the Toiyabe National Forest (B. Tkacz, Region 4, Ogden).

X Surveys

A. To evaluate the accuracy of the roadside survey technique, a combination road/plot dwarf mistletoe survey of ponderosa pine was conducted on the Roosevelt, Pike and San Juan National Forests in Colorado. Occurrence of Arceuthobium vaginatum was recorded along roads to the nearest .08 km for distances up to 1.6 km. A row of plots was then established at 100-meter intervals 40 meters from and parallel to the surveyed road. Regression analyses of the data were performed to determine if the amount of dwarf mistletoe infection observed from the road was representative of the amount of infection occurring a short distance into the forest. A coefficient of determination (R^2) value of 0.88 was achieved for all three national forests combined, showing a high correlation between roadside and plot formation. Data were also grouped according to the dwarf mistletoe infection categories originally assigned (none, low, medium, and high) and were analyzed using a paried T-test to determine if mean percentages of roadside and plots infested were similar in each of the four categories. No significant differences were found between roadside and plot means in each of the four categories. The roadside survey procedure provides an adequate estimate of the proportion of P. ponderosa infested with dwarf mistletoe, without bias according to the dwarf mistletoe infection categories assigned from roadside observations (Laura Merrill and F. G. Hawksworth, RM Station; W. R. Jacobi and John Laut, CSU; D. W. Johnson, Region 2, Denver).

B. Presuppression surveys for A. americanum are planned for 12,300 acres on the Pike and San Isabel, Gunnison, Routt and Shoshone National Forests (D. W. Johnson, USDA Forest Service, Region 2).

C. Provided funding to supplement additional cost of collecting pest information, including dwarf mistletoe data, through routine forest stand examination. The 1983 target is 179,000 acres. Pest recognition training was provided to over 100 seasonal stand examination personnel. Anticipated computer programs that access and interface the stand examination data base will provide future information on pest incidence, volume affected, correlations of pest damage with habitat types, topographic or edaphic features and so forth (J. Hoffman, USDA Forest Service, Region 4).

D. Surveyed 2,422 acres of proposed dwarf mistletoe control projects on the Ashley, Bridger-Teton, Dixie, Toiyabe, and Wasatch National Forests. The pathogens included: A. americanum, A. campylopodum, A. vaginatum. Provided partial funding for stand examinations to provide dwarf mistletoe data on 26,700 acres on the Ashley, Bridger-Teton, Dixie, and Manti-LaSal National Forests (B. Tkacz, Region 4, Oregon).

XI Miscellaneous

A. A study established in 1980 at the Institute of Forest Genetics to test resistance of Jeffrey pines to infection by A. campylopodum is beginning to show some interesting results. As of summer 1983, none of the resistant candidates have become infected whereas 41 infections have developed from inoculations placed on "nonresistant" candidate pines. Further development of infection is being followed and seedlings of both resistant and nonresistant candidates are being propagated for field testing in naturally infected stands in 1982 (R. F. Scharpf, B. Kinlock, J. Jenkinson; PSW).

B. Two dwarf mistletoe related manuscripts have recently been published in Plant Disease. They are: (a) temperature-influenced growth and pathogenicity of Cytospora abietis on white fir, 67: 137-139, 1983; (b) growth of Cytospora abietis on media made from dwarf mistletoe-infected and uninfected branch tissue of red fir, 67: 656-657, 1983 (R. F. Scharpf, PSW).

C. Cooperating with Cooperative Forestry Westwide Management Specialist in developing a mistletoe extension to PROGNOSIS (O. J. Dooling, CFPM, Region 1).

ROOT DISEASE COMMITTEE
HIGHLIGHTS OF THE 1983 MEETING
GREG FILIP, CHAIRMAN

Several topics were discussed at a luncheon meeting. Forest-wide survey techniques comprised a major portion of the discussion since several Regions are actively involved in large-scale surveys. Very few reports were submitted for the proceedings, and those that were are included here in their entirety.

ROOT DISEASE COMMITTEE REPORT
USFS, R-1, MISSOULA, MT.

Compartment Exam Survey for Root Disease

Forests and Districts in Region 1 use compartment exams to inventory stands in an entire drainage, often an area of several thousand acres. Two Districts, the Thompson Falls District on the Lolo National Forest and the Fernan District of the Idaho Panhandle National Forest, were funded to demonstrate the collection of root disease loss data as a part of compartment exams. The intent is to make the collection of root disease data, now collected sporadically, a routine part of compartment exams.

The data from aerial photos and the compartment exam will be used to develop a map and an area prescription for the drainage. The prescription will include an estimate of the amount of root disease, a summary of timber types and tree species affected, and a plan that schedules harvest and prescribes treatments in affected stands. Byler, Cooperative Forestry and Pest Management, Region 1.

Regeneration - Permanent Plots

Forest Pest Management in the Northern Region is in the process of establishing permanent plots in young growth stands with *Armillaria mellea* mortality. Trees in the plots are tagged and their location and degree of infection recorded. This information will enable us to observe the progress of the pathogen and host species susceptibility. These stands will be precommercially thinned and any resulting effects on the disease will be monitored every 5 years. The scope of the survey may be expanded in the future to include commercially thinned stands. Stewart, Cooperative Forestry and Pest Management, Region 1.

Thinned Polesized Stand Survey

A 40-year-old Douglas-fir and ponderosa pine stand was precommercially thinned 8 years ago. There is considerable Armillaria mortality in the Douglas-fir now. The stand was evaluated for mortality; distance to nearest Armillaria-infested stump was measured. Of the Douglas-fir, 17.5 percent were dead, an additional 8.6 percent had crown symptoms, and 0.5 percent of the ponderosa pine were dead. Mortality was occurring in small patches and single trees scattered throughout the stand. Dubreuil, Cooperative Forestry and Pest Management, Region 1.

Management Demonstration

Establishment of an Armillaria root rot demonstration has just been completed. Clearcutting with regeneration of various combinations of larch, ponderosa pine and Douglas-fir; larch and ponderosa pine seedtrees; clearcut with stump removal; overstory removal with thinning to release understory; and commercial thinning are being demonstrated in a 300-acre area heavily impacted by root disease. Dubreuil, Cooperative Forestry and Pest Management, Region 1.

Sanitation/Salvage Evaluation

Effects of sanitation/salvage in a stand with Armillaria root disease is being evaluated by monitoring all trees on three-fourths of an acre. Douglas-fir mortality is proceeding at a fast rate, but there is no mortality in the pine or larch components. Dubreuil, Cooperative Forestry and Pest Management, Region 1.

Commercial Thinning Evaluation

Effects of commercial thinning are being evaluated in two stands presently with low mortality rates. One stand is primarily subalpine fir with annosus root rot and Armillaria root rot and the second is a pure Douglas-fir stand with

Phaeolus schweinitzii and *Armillaria* root rot. Uncut control areas will be monitored for contrast. Dubreuil, Cooperative Forestry and Pest Management, Region 1.

ROOT DISEASE COMMITTEE REPORT
B. TKACZ
USFS, R-4, OGDEN FIELD OFFICE

1. Armillaria Root Rot

Armillaria mellea was found killing lodgepole pine regeneration on the Bridger-Teton and Wasatch National Forests. *A. mellea*, in combination with *Fomes annosus*, and western balsam bark beetle, was found killing subalpine fir throughout the spruce-fir type in the Intermountain Region.

2. Annosus Root Rot

Ground surveys of two spruce-fir stands in central and southern Utah indicate high levels of infection of subalpine fir. Twenty-three percent of the subalpine fir were infected or killed by *F. annosus* in a stand on the Dixie NF, and 34 percent were infected or killed in a stand on the Fishlake NF. Many of the trees were also infested with the western balsam bark beetle, *Dryocoetes confusus*. Aerial surveys indicate similar mortality throughout the spruce-fir type of the Intermountain Region.

3. Tomentosus Root Rot

A ground survey of a 1,300-acre blue and Engelmann spruce stand on the Dixie NF indicated that 9 percent of the trees had been killed, and an additional 29 percent were infected with *Inonotus tomentosus*. Identification was based on isolations from decayed wood samples and fruiting bodies. Fruiting bodies were identified by Dr. R. L. Gilbertson. A disease management demonstration area is being established in the stand. Treatments include inoculum removal and rotation with aspen. Permanent plots are being established to determine effects of cutting, site preparation, and regeneration on disease severity in the succeeding stand, rate of disease spread, and viability and pathogenicity of *I. tomentosus* from stumps over time. *I. tomentosus* was also found causing root rot in another 2,000-acre stand on the Dixie NF. Surveys are planned for FY 1984.

ROOT DISEASE COMMITTEE REPORT
D.W. JOHNSON
USFS, R-2, LAKEWOOD, CO.

The incidence of root disease (*A. mellea*) and ponderosa pine dwarf mistletoe in mountain pine beetle (MPB)-killed ponderosa pine in the Colorado Front Range was evaluated in 1981. Ground plots previously evaluated for MPB-killed ponderosa pine as part of a regional impact survey were revisited. A total of 175 trees on nine 5-acre plots were examined and 54.9% had only *A. mellea* and MPB, 6.9% had only dwarf mistletoe and MPB, and 6.9% had *A. mellea*, dwarf mistletoe, and MPB. In summary, 68.7% of all dead trees had either *A. mellea*, dwarf mistletoe, or both.

A cooperative study between the Rocky Mountain Forest and Range Experiment Station and FPM was conducted in the fall of 1982 to determine the relationship between the presence of root diseases, MPB infestation, and ponderosa pine mortality in the Black Hills National Forest. A total of 115 trees were examined on 40 plots. A significant association was found between tree mortality attributed to MPB and the presence of Armillaria root rot in sample trees. There was no difference between plots on the limestone and crystalline soil types. Also, there was no apparent relationship between stand structure and root infection. It appears that *A. mellea*-infected pine serve as foci for MPB attacks during endemic beetle cycles. Additional work is planned in 1983.

Interim Program Chairman's Report

Jack P. Marshall

The following comments/suggestions/ topics were suggested for the 32nd WIFDWC meeting at Taos, NM, in 1984.

1. Move business meeting from last day of WIFDWC when attendance is low to beginning of WIFDWC.

2. Reschedule canceled 1983 panel: Disease surveys, impact assessment, computer mapping, and data management.

3. Economics of Phellinus root disease control--western Oregon, Washington, and B.C.

4. Another nursery disease panel.

5. Report on the estimated pest-caused losses in western U.S., which will be compiled for the 1984 RPA update. Combine with a report from F.S. W.O. on how these figures (estimates) have been and will be used.

6. Workshop on use of computer simulation models. Hands-on exposure to RMYLD, GENGYM, ECOSIM, PROGNOSIS--for disease and insect management.

7. Impact Assessment Panel.

8. Habitat types in the Southwest--how they differ from the northern Rockies and possible relationships to disease occurrence.

9. Another workshop like Gilbertson's at Fallen Leaf Lake in 1982; except select another group of fungi--possibly imperfects, or specialty groups like nursery disease fungi, etc.

10. Special presentations by local university personnel, etc., on improving presentations via improved visuals, graphic arts, elocution, etc.

11. Panel: Habitat types associated with disease (general).

12. Workshop: Close-up photography, in-field and in-lab.

13. Report on the Australia meeting in 1983.

TREASURER'S REPORT

Date	Withdraw	Deposit	Balance
30 Sept. 1982 Balance after thirtieth meeting			$1,320.58
Misc. deposit for purchase of old Proceedings and interest		$ 57.56	1,378.14
4 Jan. 1983 Printing Proceedings	$ 709.00		669.14
6 Jan. 1983 Misc. deposit for purchase of old Proceedings and interest		23.56	692.70
Aug. 1983 Thirty-first WIFDWC statement:			
Receipts: Registration		1,860.00	
Dwarf mistletoe luncheon (25 people)		150.00	
Root disease luncheon (31 people		186.00	
Cruise Banquet (74 people)		1,110.00	
Misc. sale of old Proceedings		36.00	
Total from 31st Conference		$3,342.00	$4,034.70
Expenses for Conference	$2,891.07		$1,143.63
printing Proceedings	$ 590.00		553.63

Ken Russell maintains our deposit at:

Washington State Employees Credit Union
P. O. Box WSECU
Olympia, WA 98507
Account No. 936258

A. Forest Disease Surveys--General

71-A-4 Appraisal of damage caused by forest pests in British Columbia (R. Alfaro, G. Van Sickle).

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

71-A-7 Disease sampling in Douglas-fir plantations (G. Wallis).

71-A-9 Forest insect and disease survey in the prairie Provinces, Yukon, and Northwest Territories (Y. Hiratsuka, H. Wong).

73-A-4 Forest disease: diagnostic and taxonomic services and research (J. Hopkins, R. Hunt).

74-A-1 Disease (and insect) detection surveys in Colorado forests (J. Laut, M. Schomaker).

76-A-1 Annual disease and insect detection surveys in Idaho forests (J. Schwandt, R. Livingston).

79-A-1 DISACC: a computerized access and analysis system for forest tree problems (A. Partridge).

79-A-2 Standardizing damage estimation procedures for inventory foresters: a pictorial system (A. Partridge).

80-A-1 Standard damage estimating systems for major disease and insect problems in the inland Northwest (A. Partridge).

81-A-1 Pilot testing in R-3 of the pest damage inventory procedures developed in R-5 to provide estimates on disease losses for FIDIS (E. Wood).

81-A-2 Region-wide surveys to establish impacts of root rots for FIDIS (D. Johnson, E. Sharon).

81-A-3 Appraisal of damage caused by forest pests in the prairie Provinces (B. Moody).

81-A-5 Evaluation of disease occurrence and conifer family/disease occurrence associations in intermountain tree improvement plantations (J. Hoffman, J. Marshall).

81-A-6 Mortality of *Chamaecyparis nootkatensis* in southeast Alaska (T. Shaw, T. Laurent).

82-A-1 Root disease impact surveys of National Forests of northern Idaho and western Montana (R. James, C. Stewart).

82-A-2 Pest damage inventory to evaluate one-year mortality on the San Bernardino NF (G. DeNitto).

82-A-3 Disease and insect impact on young-growth, mixed-conifer stands (J. Pronos, L. Dolph).

83-A-1 Two-stage sampling for tree mortality in the true fir timber type on the Ochoco and Fremont National Forests (C. Schmitt, D. Goheen).

83-A-2 Pest damage surveys in Inland Empire Tree Improvement plantings (O. Dooling, J. Dewey).

B. Noninfectious Diseases

68-B-1 Detection of chronic photochemical oxident injury to conifers by remote sensing (P. Miller, R. Bega, R. Heller).

68-B-2 Physiological impact on ponderosa pine growing under natural conditions of chronic exposure to oxidant air pollution (P. Miller).

71-B-1 Influence of the forest canopy on total oxident concentrations (P. Miller).

71-B-2 The effect of atmospheric effluents on the forest (D. Hocking, S. Malhotra).

72-B-1 Effects of smoke on forest disease fungi (J. Parmeter).

72-B-2 Chronic effect of photochemical oxident air pollution on the composition of the pondeorsa pine-sugar pine-fir forest cover type (P. Miller).

78-B-2 Evaluation of air pollution effects on ponderosa pine in the Colorado Front Range (E. Sharon).

80-B-2 Trend of ozone injury to conifers in the southern Sierra Nevada (J. Pronos, D. Vogler).

81-B-1 Establishment of a network of air pollution (ozone injury) trend plots in the central Sierra Nevada National Forests (J. Allison).

82-B-1 Evaluation of ozone injury to conifers in the central Sierra Nevada (J. Allison).

82-B-2 Monitoring of ozone levels in the central and southern Sierra Nevada (J. Allison).

82-B-3 Evaluation of sulfur dioxide levels on the Inyo NF (R. S. Smith).

C. Cone, Seed, and Seedling Diseases

71-C-1 Occurrence of endophytic fungi in conifer seedlings (W. Bloomberg).

76-C-1 Diseases of seeds and cones. PC-14-246 (J. Sutherland).

76-C-2 Simulation of forest nursery diseases. PC-40-157 (W. Bloomberg).

76-C-3 Potential of several species of Phytophthora for damage to coniferous forests and forest nurseries (E. Hansen, P. Hamm).

77-C-1 Nursery disease problems at the Albuquerque Tree Nursery (E. Wood, J. Riffle).

78-C-2 Greenhouse and nursery pathogenicity and symptomatology of four soil-borne fungi on five commercial species of conifers at various ages of growth (R. Bega).

79-C-1 Chemical and bioloical control of soil-borne fungi on several conifer species at the Institute of Forest Genetics nursery (R. Bega, A. McCain).

79-C-4 Identification of fungi on Northern Region conifer seed, their detrimental effects, and methods to reduce detrimental effects (J. Woo, R. James).

80-C-2 Sugar pine hypocotyl rot in California forest nurseries. Etiology, inoculum sources, and host-parasite physiology (K. Brownell).

80-C-3 Effects of herbicides on mycorrhizae development of conifer seedlings in Rocky Mountain-Great Basin tree nurseries (A. Harvey, R. Ryker).

80-C-4 Pathogenesis of Fusarium on sugar pine at the Medford Nursery (C. Li, W. Thies, E. Nelson).

80-C-5 Detection, identification, and quantification of impact of fungi on developing cones and seeds of Douglas-fir and western white pine (S. Cooley).

80-C-7 Parameters to describe normal and disease tree seedlings (A. Partridge).

80-C-8 Effect of sowing date on root disease and seedling growth in sugar pine (R. Bega, A. McCain, J. Jenkinson).

81-C-5 Reduction of pathogenic soil fungi in a forest nursery using solar radiation (Hildebrand).

81-C-7 Control of nursery pahogens and weeds by solarization (S. Cooley).

81-C-8 Control of Meria laricis on larch seedlings with fungicides (S. Cooley).

81-C-9 Control of Phytophthora root rot of true fir with Subdue (Ridomil) (S. Cooley).

81-C-10 Outplanting success of larch seedlings infected with Meria laricis (S. Cooley).

81-C-11 Outplanting success of noble fir seedlings grown in Phytopthora-infested soil (S. Cooley).

81-C-12 Benomyl and captan residues and biological activities in forest nursery soils (C. Li, E. Nelson).

81-C-14 Survival and growth of seedlings in root disease centers (E. Militante, A. Partridge).

81-C-15 Pathogenicities and modes of infection of some fungi isolated from seeds and symptomatic seedlings of conifers (B. Advincola, A. Partridge).

81-C-16 Influence of pH and temperature on growth of and infection by a Cylindrocarpon sp. (B. Advincola, A. Partridge).

81-C-17 Root disease fungi of conifer seedlings not previously reported in the inland northwestern United States (B. Advincola, A. Partridge).

81-C-18 Effect of soil solarization on Fusarium and Macrophomina (A. McCain, R. Bega).

81-C-19 Effect of rhizobacters on root disease and seedling growth (A. McCain, R. Bega).

82-C-1 Endomycorrhiza & seedling responses of Incense cedar (R. Bega).

82-C-2 Evaluation of seaweed applications to container seedlings for control of top height and root growth (K. Russell).

82-C-8 Conditioning, winter storage and initial field performance of containerized conifer seedlings (H. Zalasky).

82-C-9 Fungicide trial to evaluate efficacy against Phoma sp. on white fir and Sirococcus strobilinus (J. Kliejunas, J. Allision, A. McCain).

83-C-1 Needle cast of western larch seedlings at the Coeur d'Alene Nursery (R. James).

83-C-2 Assessment of new chemicals to control Botrytis blight in nurseries (R. James).

83-C-3 Fungi associated with pine seedling tip blight in Northern Rocky Mountain nurseries (R. James).

83-C-4 Fusarium root disease of western white pine seedlings at the Coeur d'Alene Nursery (R. James).

83-C-5 Nematode population assessment and control in Fantasy Farms Nursery, Idaho (S. Dubreuil).

83-C-6 Germination studies on genetically improved white pine seed (J. Schwandt).

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

66-D-1 Investigations on the occurrence and control of Fomes annosus (C. Driver).

66-D-2 Studies on the cytology and genetics of Fomes annosus (C. Driver).

66-D-3 Studies on the effects of site treatments (slash burning, fertilization, mechanical soil disturbance, etc.) on limiting the abilities of Phellinus weirii to infect the regenerating stand (C. Driver).

69-D-3 Relative species susceptibility to Phellinus weirii infection (E. Nelson).

71-D-2 Phellinus weirii root rot: biology and control (G. Wallis, D. Morrison).

71-D-3 Fomes annosus root and butt rot: biology and control (D. Morrison).

72-D-2 Armillaria mellea root disease: development and testing of stand management guidelines (D. Morrison).

73-D-1 Testing native conifer plantings for resistance to Phellinus weirii (K. Russell).

73-D-2 Testing red alder plantings to reduce Phellinus weirii development (K. Russell).

73-D-3 Alnus rubra as a biological control agent for Phellinus weirii (E. Hansen, E. Nelson, J. Trappe).

73-D-4 Taxonomy and distribution of the endomycorrhizal fungi of the family Endogonaceae (J. Trappe).

74-D-7 The role of ectomycorrhizas in conversion of nitrogen from inorganic to organic forms (C. Reid, R. France).

74-D-8 Selection and induction of drought resistance in trees from ecotypes of the Colorado Front Range: interaction of tree ecotype with its mycorrhizal symbiant (C. Reid, M. Cline).

75-D-1 Stump pushing in eastern Washington to control Phellinus weirii and subsequent performance of six planted conifers (K. Russell).

76-D-4 Simulation of root rot impact in second-growth coastal Douglas-fir stands (W. Bloomberg, G. Wallis).

76-D-5 Fertilization and root disruption to control laminated root rot of Douglas-fir (W. Thies, E. Nelson).

76-D-8 Evaluation of the rate of spread of black stian root disease, Verticicladiella wagnerii, in plantations (D. Goheen).

77-D-1 Characterization of zone lines formed on artificial media and in wood by Phellinus weirii (C. Li).

77-D-13 Inoculation of ponderosa pine seedlings with Pisolithus tinctorius (J. Riffle).

77-D-14 Evaluation of Pisolithus tinctorius inoculum produced by Abbott Laboratories for ectomycorrhizal development on pine species in container and bareroot nurseries in the Great Plains (J. Riffle).

77-D-15 Stump pushing in western Washington to control Phellinus weirii and subsequent performance of planted Douglas-fir and western hemlock (K. Russell).

78-D-1 Lab, greenhouse, and nursery tests on effect of six mycorrhizal fungi on five species of conifers (R. Bega).

78-D-5 Survival of Phellinus weirii in residual roots following stump removal and nitrogen fertilization (W. Thies).

78-D-6 Occurrence of Phellinus weirii beyond visible limits of infection (W. Thies).

78-D-7 Growth loss of Douglas-fir infected by Phellinus weirii (W. Thies).

78-D-8 Chemical control of Armillaria root rot near Glenwood, Washington (K. Russell).

78-D-9 Fomes annosus in thinned and chemically treated hemlock stands in Olympic Peninsula, Washington (D. Chavez, C. Driver, R. Edmonds, K. Russell).

79-D01 Surveys of root diseases in managed conifer stands in R-2 (D. Johnson, E. Sharon).

79-D-2 Fomes annosus on true firs in Colorado: distribution and impact (D. Johnson, E. Sharon).

79-D-3 Verticicladiella wagnerii on pinyon pine at Mesa Verde National Park: disease spread characteristics and vector relationships (D. Johnson, K. Lister, E. Sharon).

79-D-5 Spread of Armillaria mellea disease centers in managed pine stands (D. Johnson, E. Sharon).

79-D-9 Evaluation of effects of precommerical thinning in 10- to 20-year-old Douglas-fir plantations infected with Armillsria root rot in Oregon and Washington (G. Filip).

79-D-11 Evaluation of timber loss due to root disease in the Wagon Sale area, Sisters Ranger District, Deschutes National Forest, Oregon (G. Filip).

79-D-13 Comparison of root disease incidence in plantations of local versus nonlocal seed source stock (D. Goheen).

70-D-14 Occurrence of airborne spores of Fomes annosus at forest sites in southeast Alaska (T. Shaw).

79-D-15 Infection of Sitka spruce and western hemlock thinning stumps by Fomes annosus in southeast Alaska (T. Shaw).

79-D-16 Relative abundance of conidia and basidiospores of Fomes annosus in airborne inoculum (T. Shaw, E. Florance).

79-D-17 Evaluation of the incidence and impact of Fomes annosus in California fir stands (G. Slaughter, J. Mihaill, J. Parmeter).

79-D-18 Evaluation of borax stump treatment for control of Fomes annosus in California fir stands (M. Schultz, J. Parmeter).

79-D-21 Displacement of Phellinus weirii from stumps by the antagonist, Trichoderma viride (E. Nelson, W. Thies).

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

79-D-23 Susceptibility of Pacific Northwest conifers to laminated root rot (W. Thies, E. Nelson).

79-D-24 Conifer culture with roots in nutrient mist (A. Harvey).

79-D-25 Spatial relations of tree species in root disease areas (N. Martin).

79-D-26 Fungi and insects associated with and causing black stain root disease in Idaho (A. Partridge).

79-D-29 Evaluation of selected mycorrhizal fungi for improving the survival and growth of container-grown Sitka spruce in southeast Alaska (T. Shaw).

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

80-D-2 Black stian root disease of western North American conifers (F. Cobb).

80-D-3 Distribution and activity of conifer mycorrhizae in Rocky Mountain forest ecosystems: impacts of disturbance, species, and age (A. Harvey).

80-D-4 Effects of fire management and intensive forest utilization on soil nitrogen status in northern Rocky Mountain timber types (M. Jurgensen, A. Harvey).

80-D-5 Evaluation of effects of precommercial thinning in 10- to 20-year-old red fir plantations infected with Armillaria root rot in southern Oregon (G. Filip).

80-D-7 Losses caused by black stain root disease in intensively managed Douglas-fir stands, Coos Bay District, BLM (D. Goheen).

80-D-9 Biology and management of Phellinus weirii (E. Hansen).

80-D-10 Identification and characterization of high and low laminated root rot hazard sites in the coastal Douglas-fir region (E. Hansen).

80-D-11 Insect-fungus interactions in the development of black stain root disease in Douglas-fir (E. Hansen).

80-D-12 Occurrence of Phytophthora lateralis in the forests of California (J. Klienjunes, D. Adams).

80-D-13 Systems of organisms causing black stain in pine roots (A. Partridge).

81-D-1 Black stain root disease: biology and control (R. Hunt, D. Morrison).

81-D-2 Growth loss of Douglas-fir caused by Phellinus weirii (W. Bloomberg).

81-D-4 Monitoring root diseases in northern Idaho forests (J. Schwandt).

81-D-5 Impacts of root disease control measures by silvicultural means on soil and site productivity (R. Smith, E. Noss).

81-D-6 Evaluation of factors contributing to Armillaria root disease risk to conifer regeneration on potential stand conversion sites in the upper peninsula of Michigan (J. Bruhn).

81-D-7 Mortality caused by Fomes annosus in 10- to 20-year-old lodgepole pine plantations in central Oregon (C. Schmitt).

81-D-10 Effects of selected silvicultural treatments on root disease development in the Northern Region (S. Dubreuil, N. Martin, R. James).

81-D-11 Odontia bicolor in coniferous root wood (C. Bertagnole, A. Partridge).

81-D-12 Hylurgops porosus as a possible carrier of Verticicladiella spp. (C. Bertagnole, A. Partridge).

81-D-13 Some conditions affecting the growth of Perenniporia subacida in culture and in wood (M. Chang, A. Partridge).

81-D-14 Phellinus weirii and Phellinus furrugineo-fuscus in wood: penetration and modes of action (E. Militante, A. Partridge).

81-D-15 Insect attractants produced by some Verticicladiella spp. and pine hosts (C. Bertagnole, A. Partridge).

81-D-16 Root disease agents associated with subalpine fir mortality in central and southern Utah (B. Tkacz).

81-D-17 Identification of root pathogens and development of root disease management strategies in southern Utah spruce forests (B. Tkacz).

81-D-18 Longevity and spread of Fomes annosus in a BLM ponderosa pine plantation (J. Marshall, J. Hoffman).

81-D-20 Infection, development, and survival of Fomes annosus in large hemlock stumps created by clearcutting (B. Van der Kamp).

82-D-1 The application of chloropicrin or methyl isothiocyanate to live trees to control laminated root rot (caused by Phellinus weirii) (W. Thies).

82-D-2 The application of chloropicrin or Vorlex to infected stumps to eradicate Phellinus weirii (W. Thies, E. Nelson).

82-D-3 Endemic ectomycorrhizal fungi of ponderosa pine in central Great Plains plantings: identification of fungi and synthesis of ectomycorrhizae (J. Riffle).

82-D-4 Demonstration of Armillaria root disease control methods (S. Dubreuil, R. Becker).

82-D-5 Assessment of root disease development in young managed stands and plantations (J. Byler, C. Stewart, R. James).

82-D-6 Development of Armillaria root disease in commercially thinned natural stands (S. Dubreuil).

82-D-7 Armillaria root rot of young intensively managed lodgepole pine stands of Alberta (Y. Hiratsuka).

82-D-8 Resistance screening of Port-Orford cedar to Phytophthora lateralis root rot (E. Hansen, P. Hamm).

82-D-9 Effect of precommercial thinning on development of black stain in root disease (E. Hansen, W. Thies, J. Witcosky).

82-D-10 Evaluation of the association of Mountain pine beetle and Armillaria in ponderosa pine in the Black Hills, South Dakota (G. Lessard, D. Johnson, T. Hinds).

83-D-1 Variability of decay potential in various isolates of Fomes annosus (S. Frankel, R. Edmonds, C. Driver).

83-D-2 Economics of controlling laminated root rot in Pacific Northwest forests (G. Filip and M. Wiitala).

83-D-3 Evaluation of silvicultural, chemical and mechanical barriers to limit spread of black stain root disease centers in pinyon (D. Johnson and E. Sharon).

83-D-4 Evaluation of bark beetle aerial survey maps for root disease detection (S. Dubreuil, J. Byler).

83-D-5 Intensification of mortality from Armillaria following sanitation/salvage (S. Dubreuil, R. Becker).

83-D-6 Fomes annosus: evaluation of methods to prevent introudction into and to remove existing inoculum from ponderosa pine stands on the Payette National Forest (R. Williams).

83-D-7 Longevity and spread of annosus root disease in ponderosa pine plantations (J. Marshall).

83-D-8 Spruce root disease survey at Prince George, B.C. (Merler, B. Van der Kamp).

83-D-9 Volume losses in Gold Creek root diseae center (C. Stewart, J. Byler).

83-D-10 Root disease impact on precommercially thinned stands (C. Stewart, J. Byler).

83-D-11 Tree growth and Phellinus weirii survival in stumps following application of sewage sludge (C. Driver).

83-D-12 Ecology of mycorrhizae in Douglas-fir: uptake of nitrogen, particularly organic forms (Bledsoe, Zusoski, R. Edmonds).

83-D-13 Ecology of mycorrhizae in Douglas-fir: biomass and productivity in relation to stand age and site quality (R. Edmonds, Vogt).

83-D-14 Bark beetle/fire/root disease interactions (Gara, C. Driver, Littke).

83-D-15 Effects of Fomes annosus on western hemlock pulp yield and quality (Jordon, R. Edmonds, C. Driver).

83-D-16 'Chemical screening for stump protection against Fomes annosus (R. Hu, R. Edmonds, C. Driver).

83-D-17 Fomes annosus spore production and deposition in commercially and precommercially thinned stands (Leslie, R. Edmonds, C. Driver).

E. Foliage Diseases

74-E-1 Inheritance of resistance to Rhabdocline pseudotsuage in Douglas-fir (G. McDonald, G. Rehfeldt).

76-E-2 Evaluation of the growth impact of Rhabdocline pseudotsugae on sapling Douglas-fir in western Oregon (D. Goheen).

77-E-1 Dothistroma pini resistance in ponderosa pine (G. Peterson).

77-E-2 Inheritance of resistance to Dothistroma pini in Austrian pine (G. Peterson, D. Van Haverbeke).

77-E-4 Resistance to Phomopsis juniperovora in geographic sources of Juniperus virginiana and J. scopulorum (G. Peterson).

81-E-2 Impact (growth loss and mortality) of Hypodermella laricis and larch casebearer on western larch in northeastern Washington (D. Goheen).

81-E-3 Impact (growth loss and mortality) of Meria laricis and larch casebearer on western larch in eastern Oregon (J. Hadfield).

81-E-4 Fungicidal control of Swiss needle cast in Douglas-fir Christmas tree plantations in northwestern Oregon (J. Hadfield).

81-E-6 Identification of needle fungi associated with the "grey beard" needle disease of pines (R. Williams).

81-E-7 Growth of germ tubes positively directed toward stomates--is this a common phenomenon of fungi infecting plant foliage? (G. Peterson).

82-E-1 Helicopter fungicide applications to control Swiss needle cast in 8-12 year-old Douglas-fir forest plantings (K. Russell).

82-E-3 Dothistroma pini of ponderosa pine in northern Idaho (R. James).

83-E-1 Diplodia tip blight in the Black Hills of South Dakota (D. Johnson, G. Peterson, Dorset).

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

83-E-3 Swiss needle cast ecology and impact in northern Montana Christmas trees (S. Dubreuil).

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

62-F-1 Life tables for lodgepole pine and ponderosa pine dwarf mistletoe (F. Hawksworth, T. Hinds).

62-F-2 Ecology of lodgepole and ponderosa pine dwarf mistletoes (F. Hawksworth).

62-F-4 Taxonomy, hosts, and distribution of Arceuthobium (F. Hawksworth, D. Wiens).

62-F-5 Silvicultural control of ponderosa pine dwarf mistletoe in the Southwest (F. Hawksworth).

63-F-1 Spread and intensification of dwarf mistletoe in ponderosa and Jeffrey pines in California (R. Scharpf, J. Parmeter).

65-F-1 The effect of dwarf mistletoe on growth of western hemlock (K. Russell).

68-F-4 Spread and intensification of dwarf mistletoe in young unistoried stands of western larch, Douglas-fir, and lodgepole pine with controlled stocking (N. Martin).

69-F-1 Effectiveness of dwarf mistletoe control following special DM - precommercial thinnings in ponderosa pine and Douglas-fir (K. Russell).

71-F-1 Growth impact, associated mortality, and spread and intensification of dwarf mistletoe in stands of Douglas-fir, lodgepole pine, and western larch (O. Dooling, N. Martin).

71-F-2 Dwarf mistletoe control in rural and suburban residential developments (J. Laut, F. Hawksworth).

72-F-1 Simulation of the effects of dwarf mistletoe in ponderosa pine and lodgepole pine stands (F. Hawksworth, T. Hinds, C. Edminster).

76-F-4 Inoculation studies to determine the host ranges of Arceuthobium campylopodum and A. occidentale in California (W. Mark, R. Scharpf, F. Hawksworth).

76-F-5 Biology and epidemiology of a Peridermium associated with lodgepole pine dwarf mistletoe (F. Hawksworth).

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

78-F-2 Control of dwarf mistletoe-caused losses in young true fir stands by thinning (R. Smith, R. Scharpf, D. Vogler).

78-F-3 Population dynamics of dwarf msitletoe on true firs in California (R. Scharpf, J. Parmeter).

78-F-4 The effect of dwarf mistletoe on mortality and volume loss in released true fir stands (R. Scharpf).

78-F-5 Reduction of dwarf mistletoe-caused mortality of Jeffrey pines by broom pruning (R. Smith, R. Scharpf).

78-F-6 Simulation of hemlock dwarf mistletoe infection and spread (W. Bloomberg, R. Smith, A. Thomson).

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

79-F-4 Dwarf mistletoe infection in young-growth western hemlock beneath infected old-growth residuals in southeast Alaska (T. Shaw).

79-F-5 Genetics of resistance of western hemlock to dwarf mistletoe (B. van der Kamp).

79-F-6 Relationship between spread of dwarf mistletoe and stand development in western hemlock (B. van der Kamp).

79-F-7 Growth loss in managed, even-aged, dwarf mistletoe-infested stands of ponderosa pine in the Pacific Northwest (E. Nelson).

79-F-8 Impact of dwarf mistletoe in the Intermountain Region (J. Hoffman).

79-F-9 Evaluation of dwarf mistletoe effects and development of a yield program for mixed conifer stands in the Southwest (R. Mathiasen, R. Gilbertson, F. Hawskworth, C. Edminster, R. Wood).

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

80-F-4 Changes in plant growth regulators in black spruce associated with infection by eastern dwarf mistletoe (W. Livingston, M. Brenner, F. Baker, R. Blanchette, D. French).

80-F-5 Seed collection, storage, and inoculation of eastern dwarf mistletoe on black spruce and white spruce (W. Livingston, R. Blanchette, D. French).

80-F-6 Root disease fungi found on black spruce infected with eastern dwarf mistletoe (W. Livingston).

80-F-7 Evaluation of effects of dwarf mistletoe on the growth and release of understory grand fir in central Oregon (G. Filip).

80-F-8 Adaptation of RMYLD to predict yields in dwarf mistletoe-infected lodgepole pine stands in the Pacific Northwest (C. Schmitt).

81-F-1 Resistance of Jeffrey pine to dwarf mistletoe, Arceuthobium campylopodium (R. Scharpf, B. Kinlock, J. Jenkinson).

81-F-3 Interactions of dwarf mistletoe and fire in lodgepole pine forests of the central Rocky Mountains (T. Zimmerman, F. Hawksworth).

81-F-4 Development of hemlock dwarf mistletoe following precommerical thinning of infected young stands in southeast Alaska (T. Shaw, T. Laurent).

82-F-1 Evaluation of the animal vectors lodgepole pine dwarf mistletoes in Colorado (T. Nicholls, F. Hawksworth).

82-F-2 Development of a framework for a yield simulation model in uneven-aged, mistletoe infected ponderosa pine stands (H. Maffei, W. Jacobi, F. Hawskworth).

82-F-3 Evaluation of timber growth productivity of southwestern mixed conifer stands in relation to habitat types and dwarf mistletoe (R. Mathiasen).

82-F-4 Dwarf mistletoe-related mortality of ponerosa and Jeffrey pines in campgrounds in California (D. Vogler, R. Scharpf).

83-F-1 Thinning demonstration of dwarf mistletoe-infected lodgepole pine on the Targhee National Forest, Idaho (J. Hoffman).

83-F-2 Evaluation of prescribed burning for control of pine mistletoe (J. Muraro, E. Wilford).

83-F-3 Evaluation of the lodgepole pine mistletoe stand projection model LPMIST (J. Laut, J. Muir).

G. Stem Diseases: Stains, and Decays

63-G-1 A study of Ophiostomaceae wood staining fungi in North America (R. Davidson).

72-G-2 Characterization and development of heartwood stain in Populus trichocarpa (A. Gokhele).

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

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

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

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

79-G-1 Evaluation of decay in released stands of advanced grand and white fir regeneration in eastern Oregon and Washington (G. Filip, P. Aho).

79-G-3 Phellinus robineae stem decay of black locust: distribution, damage, and biology (J. Riffle).

79-G-4 Decay associated with logging wounds in young-growth white fir and red fir in northern California (P. Aho, R. Smith, G. Fiddler).

79-G-5 Decays and cavity nesting birds in the Pacific Northwest (A. Partridge).

79-G-7 Improved methods for identifying cultures of common wood-inhabiting fungi (A. Partridge).

80-G-1 Decay and height growth losses associated with Douglas-fir and grand fir tops killed by the spruce budworm in the Wenatchee and Okanogan National Forests (P. Aho).

80-G-2 The role of Actinomycetes in the discoloration and decay process of living trees (R. Blanchette).

80-G-3 Inonotus andersonii and decay of oaks in Arizona (K. Yohem, R. Gilbertson).

80-D-4 Rate of decay in mature grand fir and western hemlock infected by Echinodontium tinctorium in northern Idaho (J. Schwandt).

82-G-1 Bioactive metabolites of forest tree pathogens - Gremmeniella abietina, blue stain fungi associated with mountain pine beetle, Condrostereum purpureum, Verticicladiella spp. (Y. Hiratsuka, W. Ayer).

82-G-2 Incidence and damage caused by heart rots, primarily Hericium abietis, in old-growth Pacific silver fir-western hemlock stands on the Olympic National Forest (G. Filip).

H. Stem Diseases; Rusts and Cankers

53-H-1 Testing progeny of resistant pines for susceptibility to white pine blister rust in the Inland Empire (R. Bingham).

61-H-1 Streamlining pollination and progeny test methods in breeding for blister rust resistance in western white pine (R. Bingham).

61-H-2 Breeding and selection for climatic adaption in interspecies hybrids, toward accumulation of a pool of rust-resistance genes from other white pines of the world (R. Bingham).

66-H-1 Comparative physiology of varieties of western white pine with respect to their reaction to the blister rust fungus (R. Hoff).

66-H-4 Numbers and kinds of resistance genes and their relation to rust symptomatology (G. McDonald, R. Hoff).

66-H-5 Precise estimates of heritability and combining ability of rust resistance (G. McDonald).

66-H-6 Development and pathogenicity of Hypoxylon fuscum on northwestern species of alder (J. Rogers).

67-H-1 Etiology of aspen cankers (T. Hinds).

67-H-2 Field level of blister rust infection in early generation, partially resistant, western white pine stock (R. Hoff).

69-H-1 Thinning and pruning western white pine to control the blister rust disease (J. Byler, N. Martin).

71-H-3 Forest tree rusts of western North Ameria (Y. Hiratsuka).

71-H-4 Computer simulation of white pine blister rust disease (G. McDonald, R. Hoff).

74-H-1 Rust fungi of Cupressaceae and Taxadeae: taxonomy and life histories (R. Peterson).

74-H-4 Biology, development, and systematics of Hypoxylon and its allies (J. Rogers).

74-H-6 Seed production areas for obtaining western white pine that is genetically improved for resistance to blister rust (R. Hoff, G. McDonald).

77-H-1 Characterization of Champion Mine race of Cronartium ribicola (G. McDonald, E. Hansen).

77-H-2 White pine blister rust (R. Hunt).

79-H-1 Diplodia tip blight in the Black Hills of South Dakota (G. Peterson, D. Johnson).

79-H-4 Ecological studies of spruce rust diseases in subarctic taiga forests Coop with USFS and Univ. Alaska (J. McBeath).

79-H-5 Expansion of stalactiform blister rust cankers on lodgepole pine (T. Beard, B. Geils, N. Martin).

79-H-6 Association of stalactiform blister rust with other diseases and insects of lodgepole pine (T. Beard, N. Martin).

80-H-1 Evaluation of aspen harvesting practices in Colorado and New Mexico (D. Johnson, T. Hinds, J. Beatty).

80-H-2 A survey of the incidence and impact of stem rusts and Atropellis canker on immature lodgepole pine in British Columbia (B. van der Kamp).

80-H-4 Genetic variation of gall frequency in lodgepole and ponderosa pine seedlings inoculated with western gall rust (R. Hoff).

80-H-5 Inheritance of horizontal resistance mechanisms (R. Hoff).

80-H-6 Verification of white pine blister rust simulation (G. McDonald).

80-H-7 Pruning white pine for blister rust control (K. Russell).

80-H-8 Growth of Cronartium coleosporoides in tissue of Pinus contorta (T. Beard, N. Martin).

81-H-1 Biology, cytology, and systematics of Xylaria (J. Rogers).

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

81-H-3 The etiology of Thyronectria canker on Colorado honeylocusts (W. Jacobi).

81-H-4 Mode of penetration and tissue invasion by Endocronartium harknessii (M. Chang, A. Partridge).

81-H-5 Biology and control of stem rusts of hard pines (R. Blanchette, D. French).

81-H-6 Wood deterioration by canker-rot fungi (R. Blanchette).

82-H-1 Hazard rating and ecology of comandra blister rust in the Rocky Mtn. Region (W. Jacobi).

82-H-2 Canker diseases of honeylocust: etiology, infection, and disease development (J. Riffle, G. Peterson).

82-H-3 Guidelines for management of western white pine in the Northern Region (S. Dubreuil, G. McDonald, G. Norby).

82-H-4 Western gall rust studies in relation to the genetic improvement program of lodgepole pine (Y. Hiratsuka).

82-H-5 Incidence and intensification of blister rust on the Sierra NF (J. Kliejunas).

83-H-1 Hazard rating and ecology of comandra blister rust in the Rocky Mountain Region (W. Jacobi).

83-H-2 Economic and biological efficacy of pruning as a tool for white pine blister rust management (R. Harvey).

83-H-3 Evaluation of *Tuberculina maxima* as an aid to biological control of white pine blister rust (R. Harvey).

83-H-4 Management of lodgepole pine infected by comandra blister rust in the Rocky Mountains (B. Geils, W. Jacobi, F. Hawksworth, D. Johnson).

83-H-5 Distribution and parentage association of western gall rust infection in four ponderosa pine seed orchards (J. Hoffman, J. Marshall).

83-H-6 Methods evaluation for estimating ribes population potential in old-growth stands (S. Dubreuil).

I. Wilt and Blight Diseases

71-I-1 Dutch elm disease detection surveys in all municipalities in Colorado (J. Laut).

74-I-1 Control of Dutch elm disease using vector pheromones. Coop with USFS, NEFES, and CSFS (C. Helburg, D. Leatherman, J. Laut).

77-I-1 Distribtuion of Dutch elm disease and its principal vector, the smaller European elm bark beetle, in Montana urban areas (O. Dooling, S. Kohler).

77-I-3 *Diplodia pinea* tip blight on pines: etiology of stem infections (G. Peterson).

77-I-4 *Herpobasidium deformans* blight of honesuckle: infection and control (J. Riffle).

79-I-2 Resistance to *Cerocspora sequoiae* var. *juniperi* in geographic sources of *Juniperus virginiana* and *J. scopulorum* (G. Peterson).

80-I-1 Microbial antagonists as a biological control for Dutch elm disease (R. Blanchette).

80-I-2 Methyl bromide fumigation of oak wilt-infected oak logs (D. French).

81-I-1 *Diplodia* tip blight in the Black Hills of South Dakota (D. Johnson, G. Peterson).

J. Defects and Decays of Forest Products

58-J-1 Deterioration of beetle-killed Engelmann spruce in Colorado (T. Hinds).

68-J-2 Role of heartwood microflora in the breakdown of thujaplicin in western redcedar heartwood (B. van der Kamp).

71-J-1 Evaluation of potential wood preservatives: Thiram and Thiram-Oxathiin mixtures (R. Smith, C. Johansen).

71-J-2 Analysis of aspen chip deterioration during outside storage (R. Smith, C. Johansen).

72-J-2	Utilization of decayed wood in pulp manufacture (K. Hunt).
72-J-3	Degradation and preservative treatments of western redcedar shingles and shakes (A. Cserjesi, R. Smith, T. Littleford).
73-J-1	Interaction of fungi and chemicals--pentachlorophenol (A. Cserjesi).
76-J-1	Microdistribution and efficacy of preservatives in treated wood and their effects on microorganisms (W. Wilcox).
79-J-1	Diagnosis of wood decay (W. Wilcox).
80-J-1	Deterioration of timber following the Mt. St. Helens eruption (K. Russell).
82-J-1	Deterioration of windthrown timber in the Olympic Peninsula from the February 12, 1979, Lincoln Day storm (K. Russell).

K. Miscellaneous Studies

71-K04	Species of *Mycosparella* on Salicaceae in western interior of Canada (H. Zalasky).
71-K-5	Winter injury in poplar: a histological study (H. Zalasky).
71-K-6	Prevention of winter injury to conifers and other hardwoods (H. Zalasky).
72-K-1	The pathology of Ohia decline in Hawaii (C. Hodges).
73-K-2	Forest disease simulation model (W. Bloomberg).
73-K-3	Fungi of Washington State (J. Rogers).
77-K-5	Development of operational use of biological control of forest pests in British Columbia. PC-45 (H. Whitney).
78-K-1	Effect of thinning on the incidence and impact of *Cytospora* canker, fir engraver beetle, and *Fomes annosus* in white fir stands on the east-side Sierra Nevada (G. Ferrell, R. Scharpf, J. Parmeter).
78-K-2	Reduction in stem volume of grand fir defoliated by western spruce budworm outbreaks in the Payette National Forest, Idaho (G. Ferrell, R. Scharpf).
79-K-1	Use of the Shigometer for assessment of tree vigor and growth in 25- to 100-year-old Sitka spruce and western hemlock (T. Shaw).
79-K-2	Mortality of Douglas-fir: biotic systems and impacts (A. Partridge).
79-K-3	Management alternatives in forests with Douglas-fir mortality centers (A. Partridge).
79-K-4	Revision and update of "Keys to major disease and insects..." in color (A. Partridge).
80-K-1	Evaluation of hazardous trees in forested recreation sites and ski areas (E. Sharon, Hubbard).
80-K-2	Evaluation of diseases and their impact on Minnesota's shade trees (R. Blanchette).
80-K-3	Interactions among the pine wilt nematode, fungi, and bark beetles in the Midwest (M. Wingfield, R. Blanchette).
80-K-4	Evaluation of the Mount St. Helens eruptions on insect and disease activity in the blast area (J. Hadfield).
80-K-6	Computer programs to analyze street tree inventory data in urban areas of Idaho (J. Schwandt).
81-K-1	Comparative roles for saprophytic and pathogenic decays in Rocky Mountain forest soils: impacts of disturbance on regeneration and growth (A. Harvey, M. Larsen).

81-K-2 Life histories and anamorphs of lignicolous Pyrenomycetes (J. Rogers).

81-K-4 Reestablishment of vegetation on Mount St. Helens-created debris flow: an unusual "pathological" event (K. Russell).

82-K-1 Comprehensive pest management plan for Washington State (within the Forest Land Management Plan) (K. Russell).

82-K-2 Etiology and epidemiology of Alaska yellow cedar decline in SE Alaska (E. Hansen, P. Hennon, T. Shaw).

83-K-1 Evaluation of aspen harvesting practices in Colorado and New Mexico (T. Hinds, D. Johnson, and J. Beatty).

83-K-2 Tree diseases and their effects in recreational areas (T. Hinds, E. Sharon).

83-K-3 Hazard tree survey in Winchester State Park, Idaho (J. Schwandt).

83-K-4 Mistletoe and root disease control demonstration areas (J. Muir).

83-K-5 Recreation area vegetative management plan for Armillaria mellea, Phaeolus schweinitzii, and Endocronartium harknesii (C. Stewart, R. Yates, V. Applegate).

83-K-6 Compendium of diseases of range plants (C. Driver).

83-K-7 Ponderosa pine logging residue decomposition on the east side of the Washington Cascades (R. Edmonds, C. Driver).

Other Projects

Yvonne Beaubien from the Manitoba Department of Natural Resources attended WIFDWC this year and supplied us this list of current projects underway in the Forest Protection Section in Manitoba.

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

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

Spread of Armillaria mellea in pine plantations (K. Knowles, Y. Beaubien).

Rate of spread, volume loss and management strategies for Arceuthobium americanum on jack pine and Arceuthobium pusilum and white spruce (K. Knowles, Y. Beaubien, D. French, F. Baker).

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

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