PROCEEDINGS OF THE 40th ANNUAL WESTERN INTERNATIONAL FOREST DISEASE WORK CONFERENCE

Durango, Colorado
July, 1992

Proceedings of the 40th Annual Western International Forest Disease Work Conference

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Proceedings of the Fortieth Western International Forest Disease Work Conference
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CHAIRMAN'S WELCOME

Duncan Morrison

Forestry Canada, Pacific Forestry Centre, Victoria, B.C.

Honorary members, guests and fellow pathologists:

Welcome to the 40th Western International Forest Disease Work Conference (WIFDWC). I extend a special welcome to those of you attending your first WIFDWC, and to Roberto Velasco and Juan Olivo of the State of Chihuahua, Mexico.

Thanks to Susan Frankel, our secretary, for the mailings; to Pete Angwin for local arrangements and for yesterday's railroad excursion to Silverton; and to Terry Shaw for the program.

On the occasion of the 40th meeting of WIFDWC, it is appropriate to reflect on the history of our conference and its purpose and to give some thought to where we are going. In preparing these remarks, I browsed the bound volume containing the proceedings of the first five meetings. It was interesting to see how our conference evolved.

In November 1953, 33 delegates from western North America gathered in Victoria, B.C. The chairman was Ray Foster. They spent two and one-half days reviewing 59 pathology projects and one-half day examining work in progress at the Cowichan Research Station.

The second meeting was held in Berkeley with Willis Wagener in the chair, and included joint sessions with the entomologists.

At the third meeting in Spokane there was a printed agenda and panel speakers contributed prepared papers. Although the insect and disease conferences were held at the same time and place, no joint sessions were held because of a lack of enthusiasm in discussing a joint topic.

A one-day field trip appeared for the first time in the program of the fourth meeting. Between the fourth and fifth meetings, a committee examined the organization and affairs of the conference. The structure adopted at the fifth meeting is essentially the same one we have today.

In the 20 or so years that I have been attending WIFDWC meetings, there have been two noticeable and, in some ways, regrettable changes. First, less meeting time is spent talking about new projects, etc. This portion of the agenda had become lengthy and cumbersome. However, it was an excellent way to find out who was doing what. Second, there is much less uninhibited discussion. Session organizers need to allow more time for discussion.

The principles on which WIFDWC was founded - informality, uninhibited discussion and mass participation - are relevant today and tomorrow. During the next few days, ask questions of speakers, participate in discussion and tell your colleagues what you are doing.

Let's have a productive conference.

IN MEMORY

Ross W. Davidson
1902 - 1991

Prepared by Frank G. Hawksworth

Ross W. Davidson passed away on August 30, 1991, in Fort Collins, Colorado. He was born on August 12, 1902 in Columbus, Kansas. He obtained his B.S. from Ottawa University in Kansas in 1927 and a Masters degree in mycology from Iowa State University in 1928. On graduation from Iowa State, Ross began a long and distinguished career in forest pathology by joining the USDA Division of Forest Pathology in Washington, D.C. In 1951, he moved to Fort Collins to head up the newly established Forest Disease Laboratory. In 1957, he returned to the East to head up the Forest Disease Culture Lab in Beltsville, Maryland (predecessor of the present Center for Forest Mycology at the Forest Products Laboratory in Madison, Wisconsin) and remained there until his retirement from the USDA in 1961. But, Ross soon began a second career at the Wood Research Laboratory at Colorado State University in Fort Collins, where he continued his research on wood staining fungi for more than 20 years. This research entailed field work throughout the western United States, Alaska, Canada, and Taiwan.

During his long career, Ross authored more that 100 scientific papers on canker, wood decay, and staining fungi. While in Washington, he developed the first practical system for identifying wood decay fungi based on their cultural characteristics. Through his pioneering work he was able to establish the causal organisms of many important decays, notably the fungus that causes "pecky cypress" of bald cypress. In Colorado, Ross collaborated with Tommy Hinds on pioneering research on the cankers and decays of aspen, decay of fir and spruce, and deterioration of beetle-killed Engelmann spruce. Ross's persistence in pursuit of science is exemplified by his publication of articles in the journal *Mycologia* over a 56-year period from 1931 to 1987. We told Ross that this record was even more remarkable than Joe DiMaggio's 56-game hitting streak, and Ross, an avid baseball fan, appreciated the analogy.

Ross was the recipient of many honors, including an honorary Doctor of Science degree from Ottawa University in 1968, a certificate of appreciation from Colorado State University in 1982, and the Distinguished Mycologist Award from the Mycological Society of America in 1984. Ross was a Charter member of and ardent supporter of WIFDWC and served as Secretary-Treasurer of the fourth conference in El Paso, Texas. Ross will be remembered by all who knew him as a real Gentleman who was always willing to share his vast knowledge and wise counsel with colleagues and students alike. Ross was devoted to his family and his church. Mildred, Ross's beloved wife of 61 years, preceded him in death by about a month.

He is survived by a son, Roger, in Maryland.

Harold Offord
1903 - 1992

Prepared by Robert F. Scharpf

Harold Offord, one of the founding members of WIFDWC died in February, 1992 at the age of 89. Harold, a native of Toronto, Canada, earned Bachelors's and Master's degrees at the University of British Columbia, major in biochemistry. Harold joined the USDA Bureau of Plant Industry staff in 1926 in Berkeley, California and worked on methods of controlling white pine blister rust and other forest diseases. Harold served as pathologist in the USDA, Bureau of Entomology and Plant Quarantine (1935-52), and with the Forest

Service, California region (R-5) (1953-55). In 1956 he became Chief, Division of Forest Disease Research at the California Forest and Range Experiment Station in Berkeley, and in 1962 became project leader in charge of research on heartrots of conifers, mistletoes, and white pine blister rust. Harold retired in 1965, and he and his wife Leonore (Lee) continued to live in Berkeley for several years until they moved to Ashland, Oregon to be near their daughter Judith who worked with the Ashland Shakespeare Festival.

Harold was an active participant and supporter of WIFDWC for many years even after retirement, and during his later years when he was no longer able to attend meetings he regularly donated money for the support of WIFCWC. A generous man, respected by his friends and colleagues, he will be missed by all.

Roy Blomstrom
1908 - 1991

Prepared by Greg Blomstrom, Registered Professional Forester and Son

Roy Blomstrom, of El Cerrito, Ca died in November, 1991, in Oakland at the age of 83. Roy graduated in Forestry from Oregon State University. The majority of his forestry career was spent in California, principally in the central Sierra Nevada and in the USFS Regional Office. He retired from the Regional Office in 1973 after 42 years of service. He was a golden member of the Society of American Foresters, having been a member for 59 years. Until 1991, Roy was still actively fishing and advising younger foresters on the science and art of pest management. My sister and I intend to scatter his ashes on the Stanislaus National Forest and from the top of Mt. Kaweah, two places he knew and loved.

Warren V. Benedict
1901 - 1992

Prepared by Douglas Reed Miller

Warren Benedict's first job after finishing college was with the Bureau of Plant Industry, Office of Forest Pathology at Portland, Or. He worked for Dr. Jack Boyce scouting for white pine blister rust in British Columbia during the summer and fall of 1924.

In the spring of 1925 he worked for the same bureau but for the Office of White Pine Blister Rust as a camp boss in North Idaho. In 1926, his work was in California on Methods and Development on the Stanislaus National Forest, then in 1927 he was put in charge of blister rust work in California. In 1932 he was transferred to Berkeley, Ca after he had made a complete inventory of sugar pine. The control work was expanded with men working on blister rust control out of the CCC program and other relief programs. In this effort 375 men were put to work and Benedict received a commendation from President Roosevelt.

In July 1934, Benedict became head of the newly created Bureau of Entomology and Plant Quarantine, California Division, headquartered in Oakland, CA. In 1954 the Bureau was eliminated (due to a Senator's whim) and Benedict was transferred to the Forest Service, Washington Office and put in charge of pest control. He kept this position until he retired after 42 years of Federal service.

FOREST PATHOLOGY: ITS RELEVANCE IN THE 90'S

Pritam Singh

Forestry Canada - Science and Sustainable Development Directorate,
Hull, Quebec

It is indeed a pleasure to be invited by this group of esteemed professionals to talk about a subject which I believe is going to have considerable influence on the sustainability of an extremely valuable resource of this planet, i.e., Forests.

The title suggested to me for the talk is very general and broad. I will narrow the limits of the topic by discussing the future role of forest pathology research in forest management in 90's. In this process, I will digress a little into philosophical approaches and I will also be mostly talking from the point of Canadian forestry and Canadian forest pathology.

Coming from Canada, a country with 453 million hectares under forests, representing about 10% of the world's forests and 44% of the country's land, we are concerned not only about the management and sustainability of forests, but also about the management of our forest ecosystem. We do understand that forests are complex natural associations and we are looking at all options of management strategies. Although abundant forest resources have enabled a huge industrial base to develop and contribute to the global economy, "THE CHALLENGE" ahead is to ensure that the forests remain productive and sustainable and able to provide a share of world production, retain jobs, economic and recreational benefits, and maintain the natural biodiversity of flora and fauna.

There are several means through which we can meet "THE CHALLENGE". One of them is proper renewal and good management of our forests, including lowering of losses to fire, insects and diseases through good silviculture and more efficient and effective stand management. At the same time we must maintain our forests in a state congenial to natural biodiversity and recreation.

Generally speaking the forests in Canada are in transition, from natural forests to intensely managed plantations, from an era of over abundance to a period of tighter wood supplies. Along with this, protection of forests from pests has also changed from crisis management to effective long term management of pests, integrating the strategies with the overall management of the forest resource. Forestry has progressed from harvesting and regeneration to integrated management of the forest resource. Protection of forests from insects and diseases is a major goal of forest management. It is now regarded as an integral part of forest management and management of a forest disease is considered as an important element of the pest management strategy.

Forest pathology or research in forest tree diseases, whatever we may call it in this era of new terms and acronyms, is a subject of all times. It is more important now than it has ever been, particularly when we look from the point of view of forest health. In 1986, National Forestry Congress in Canada recommended that to ensure sustained level of wood supply at competitive costs and to provide proper forest environment, forest protection must be considered as one of the seven major elements of forest management. The Canadian Council of Forest Ministers (1987) while endorsing the National Forest Sector Strategy remarked that "failure to invest in protection will jeopardize future benefits from the forest". It is now generally recognized that insects and diseases have far too long hindered the achievement of production goals and sustainability of forests. In order to more fully realize the production potential and maintain healthy forest environment, the vigor, growth and yield of trees must be maintained and losses to destructive organisms must be minimized. Disease control or disease management is not only now considered as an integral part of pest management but of overall scheme of forest management.

As mentioned earlier our whole philosophy and approach to tree disease management is changing. As a result there is a need to -

(i) Orient and educate the future forest pathologists with newer concepts and approaches of management of forests and forest ecosystem. We need to get away from the isolationist approach of disciplines, such as forest pathologist, forest entomologist, silviculturalist, or forester. It is during this training period that "forest pathologists" need to develop a much broader outlook of forests, forest ecology and forest health, and integrate as much as possible with other aspects or disciplines of forest management; pathologists need to be involved from the very beginning. A forest pathologist has to believe in and follow the preventive approach. For that he has to integrate into forest management in the early stages of establishment of a forest or plantation, i.e., even before the stage of putting the seedlings/seeds in the ground.

(ii) Educate clients, i.e. forest industry, foresters and other forest agencies, on the role of a forest pathologist or forest health advisor. A forest pathologist is a "tree doctor" who can not only cure or treat a disease, but can also prevent it. He, along with a forester, should practice what in "human sciences" we call "preventive medicine". By becoming an integral part of forest management and sustainable growth he can surely do that. At the same time a forester has to realize that forest tree diseases are not the "glitches" or "blips" in the life history of a forest, but are an integral part of forest dynamics. They do occur, rarely or frequently, in different intensities, and at different stages of forest growth. As a result it is now imperative to avoid the onset of a disease if at all possible.

"PREVENTION IS BETTER THAN CURE FOR THE TREE AND THE ECOSYSTEM"

Whitney, Hunt & Munro (1983) reported that prevention rather than control of tree diseases should be the main emphasis of future forest management. Prevention of diseases and minimization of losses, however, depends largely on the ability of forest managers to anticipate disease problems before they develop, and to devise planting and management strategies that will result in relatively disease-free forests or stands with tolerable levels of pathogens. The principle of prevention includes inoculum reduction, keeping the trees healthy and vigorous, and avoidance of predisposition and environmental conditions that favor disease development.

In the 90's three types of approaches can be used so that forest pathology can be an integral part of forest management -

(i) Classical
(ii) Biotechnological
(iii) Better understanding of forest ecology and use of frontier technology.

I believe that we need to rely on an integrated approach, using all the above three or a combination of two or more of these approaches.

The ***Classical approach*** may require the use of standard strategies, including surveys, detection of the disease and the damage, assessment of damage, manipulation of silvicultural practices, and proper application of fungicidal treatment to coincide with the presence and abundance of the pathogen.

The ***Biotechnological approach*** is one of the recent ones; it aims to obtain a better understanding of the host-pathogen relation, which will eventually lead to better disease management strategies. We all know that forest pathology is well into newer research directions of biotechnology and is eventually leading into newer management strategies through rapid diagnosis and better understanding of diseases. Mitchell (1985) reported that the hybridoma technology, through the use of monoclonal antibodies (McAbs), offers a modern biochemical tool to seek solutions to many current disease research and management problems; these

antibodies are exquisitely specific, chemically homogeneous and sensitive diagnostic probes for detecting pathogens in complex biological systems of infected plant tissues and they are being used for:

(i) rapid and accurate presymptomatic detection of pathogens in forest nurseries, high value plantations, and seed lots; thus preventing establishment of accidentally introduced pathogen-contaminants in seed and planting stock. This kind of diagnosis can be useful in seed certification and in the quarantine of plant material, thus allowing removal of contaminated stock before the disease becomes established in a nursery or a plantation;

(ii) rapid and accurate diagnosis of pathogens and pathovars once a disease outbreak has occurred; this may assist in timely application of proper control measures, thus preventing extensive loses. For example, the occurrence of a virulent race of a pathogen may demand an immediate control effort while the prevalence of a non-virulent race may never warrant any control measure;

(iii) evaluating the efficacy of chemical treatments or other control measures;

(iv) localizing and studying the role of toxic glycopeptides in pathogen cells and their interactions within infected host tissue;

(v) detecting wood decays even before the decay fungi become established, and for differentiating pathogenic fungi from the other fungi, which are being used in the biological control of the decay system.

In 1987, Nordin and Singh suggested that many advances in molecular genetics have stimulated application of new research technologies in disease management. Isozyme profiles are being used to probe host resistance, characterize pathogen virulence, and study genetics of pathogen populations (Hubbes 1987b). The biochemical markers, such as isozymes (Hubbes 1987a, 1987b), protein patterns (Jeng 1986; Jeng and Hubbes 1983; Hubbes 1987b) and restriction length polymorphism (Anderson, et al. 1987) are being used to differentiate species and pathovars, and determine their relationship to their geographical distribution particcularly, of virulent and non-virulent forms within defined hazard zones. This may be extremely valuable in the management of root rots (such as Armillaria root rot), stem cankers (such as Scleroderris canker), stem rusts (such as white pine blister rust and western gall rust) and dwarf mistletoes. Powers, Lin and Hubbes (1986) and Hubbes (1987b), while working on pollens from loblolly pine, showed a relationship between a specific isozyme pattern of glutamate-oxaloacetate transaminase (GOT) and disease resistance of the tree, thus indicating the potential for screening host species/varieties for resistance.

The localization, identification and characterization of toxin, "cerato-ulmin", produced by a pathogen, *Ophiostoma ulmi*, may assist in obtaining a better understanding of the host-parasite relationship, including the host reaction and defense mechanisms, which could eventually lead to the development of resistant forms.

Hubbes (1981, 1986 and 1987a, 1987b; Hubbes and Jeng 1981) successfully increased the resistance of white elm seedlings to aggressive strains of *O. ulmi* by giving pre-inoculation with a non-aggressive strain of the fungus. Hubbes hypothesized that resistance to the disease can be induced by biochemical manipulation of the host's defense system or by reducing the virulence of the pathogen.

Hasnain and Cheliak (1986) reported that tissue culture in trees can also assist in the selection of disease resistant clones or for the production of genetically engineered plants resistant to diseases. In agriculture, these methods are already being applied with considerable success.

Blanchette (1987) and Nordin and Singh (1987) reported that in forest products pathology, microbial technology provides new ways to protect wood from decays and deterioration, and offered new approaches towards utilizing wood in the forest products industry. White rot fungi are being investigated for their potential as

biopulping and biobleaching agents in the pulp and paper industry; they also provide an innovative approach for treatment of waste effluents.

Nordin and Singh (1987) and Singh (1989) also reported that research on tree diseases and forest products pathology in Canada is increasingly taking advantage of frontier technology and innovative techniques, including electronics, computers and biotechnology. This is eventually leading to rapid diagnosis of diseases, better understanding of the host-parasite interactions, and development of newer disease or damage management strategies. It is also recognized that because these strategies are long term and expensive, and need more than one speciality expertise, creation of multidisciplinary teams or networks to solve many of the disease/damage problems has become not only necessary, but imperative. It must, however, be realized that although biotechnology with its most advanced tools and techniques may appear most promising, it still has its limitations. In some situations good old forest pathology may have to be relied upon for quite some time. In the meanwhile, it is also imperative to understand the behavior of the pathogen and reaction of the host. It is important not only to identify the pathogen but also to identify the virulence behavior of the pathogen and the resistant behavior of the host, so that we can manipulate these two behaviors to a balance which is beneficial to forest management and forest productivity (Hubbes l98l, 1986, 1987b). Hubbes believes that once an understanding of the genetic determinants and the related biochemical processes of disease resistance is achieved, one can induce in a very directed manner the genetic rearrangement required to engineer the resistance process in a tree. Sill (1982) also expressed that disease resistance provides the simplest and perhaps the most effective and in the long term most economic means of combating and managing a plant disease.

The ***Ecological approach*** will include understanding the distribution and severity of the pathogen in its natural environment and determining the strategies to prevent or avoid it. Bloomberg (1987), and Nordin and Singh (1987) reported that computers are playing an important role in ecological research on tree diseases through literature retrieval, efficient data processing, evaluation of disease survey and impact data, projections, graphics, and dimensional analyses of organism structures and disease processes. They also have a significant role in developing models for damage assessments and prediction of disease development and disease behavior. Although acceptance of computers for modeling in forest pathology has been slow, it has been more rapid in other fields, such as long-term databases, disease surveys, damage appraisal, and crop loss assessment. Currently computer technology is being applied for developing root-rot and dwarf mistletoe research models for surveys, impact analysis and projections; and eventually for developing management strategies for these diseases. Computers are also being used for prototyping an expert system for diagnosis of forest seedling nursery problems (Thompson, et al. 1992). Future developments in computer applications in tree disease research may also include dissemination of user-friendly microcomputer software to practitioners, validation of computer-generated estimates and predictions, forest disease behavior, use of sophisticated graphics to analyze disease processes, and incorporation of artificial intelligence in diagnostic and prescriptive methods.

Singh (1990) and Sutherland (1991) while discussing the management of tree seed and seedling pathogens, recommended the need for greater emphasis on the development of well managed seed orchards, seed collection areas and tree nurseries. They emphasized that there are greater chances of a healthier plantation if we start with healthier seeds and seedlings. Sutherland (1991) also remarked that technological development and establishment of seed orchards and container nurseries have greatly influenced the prevalence and severity of pathogens. For example, the container nurseries have practically eliminated the loses caused by damping-off which are so prevalent in bareroot nurseries. However, gray mould which seldom affects bareroot stock, has become a major health problem in container nurseries. Because much time, effort and finances are being invested in the new seed orchards and nursery facilities, it is important for foresters, with the assistance of forest pathologists, not only to become aware of new or different pest problems and losses to their high valued stock, but also become sophisticated in the management and care of their stock. Since concerns for the environment and human health has increased, foresters and nurserymen are shifting their reliance from fungicide to integrated disease management, which includes timely

detection of the disease and the pathogen, manipulation of cultural practices, better storage and handling conditions, less and most effective use of fungicides, and use of biological agents, wherever possible.

Although detection and assessment of damage will continue to be a priority, there will always be a need for obtaining a better understanding of pathogens, particularly their heterogeneity, population structure, and interactions with other microorganisms, Traditional methods of investigating diseases will continue to be useful, but they have limitations and will have to be augmented by new technologies that will eventually lead to more rapid, long term and effective solutions to forest disease problems. In the future, consideration of diseases must form an integral part of forest planning for seed production, seed storage and seed handling, rearing of seedlings, selection of planting sites, tending of stands, and harvest and utilization of mature forests. Environmental diseases, including those caused by industrial pollution and acid rain, will have increasing impact on forest stands as well as on urban amenity forests. Changes in stand history, composition and environment will encourage some diseases and discourage others in ways that are not yet fully understood. Diseases that were of little importance in old forests may become serious threats to younger stands grown under different conditions. It is hoped that in future, diseases will be studied in concert with the host and its environment, including insect pests and adverse environmental factors. Too often in the past only one of the above aspects of the problem has been addressed, although there have been some notable exceptions. Trees do have combinations of problems acting together in a disease syndrome. In 1980, Horsfall and Cowling stated: "(R)arely is disease caused by a single agent; cause is complex, and its study is just as complex...". Research on diseases in general, and such diseases in particular, will be more successful if expertise from several disciplines were brought to bear on the problem.

Lachance (1990) remarked that forest protection through integrated pest management (IPM) is the only means of reducing overall depletions and increasing forest productivity, integrated pest management is currently the accepted strategy for the management of tree diseases, with particular emphasis on the use of biologically rational measures to keep the pest populations below the levels that cause damage. It is, however, realized that in forestry the IPM technology is not as well advanced and it cannot be easily transplanted from agriculture to forestry; the process of bringing in the IPM approaches and technology in forestry will involve considerable research and development to adopt the principles and/or techniques to forests and forest conditions. Besides, some of the forest damage problems are caused by a complex of pests and other factors, and also because we deal with plant communities.

Lachance (1990) suggested that we should now replace the classical concept of "forest disease" with "forest health" which will cover, beside loss in growth, increase in productivity and disease resistance through improved health; as a result there is a need to involve forest health experts besides forest pathologists. I believe that management of diseases should be an integral part of forest health management in the overall scheme of forest management and sustainable forest growth. There is an opportunity to shape the future of forestry and forest disease management to sustain this valuable resource. Although many significant contributions have been made, there are still many opportunities. There is a greater need for closer and cooperative working relationships among researchers, disease management personnel, foresters, silviculturists, resource and research managers. It is also important to integrate the complex technical considerations of controlling/managing diseases with important social and political realities. The socio-political concerns are increasingly having greater influence on the decisions we make on how to manage diseases or the forests as a whole...

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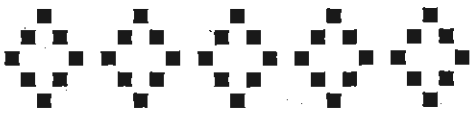

PANEL: PEST EFFECTS AT THE LANDSCAPE LEVEL -- SPACE, THE FINAL FRONTIER

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ANALYZING LANDSCAPE PATTERNS CAUSED BY FOREST PATHOGENS: A REVIEW OF THE LITERATURE

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Like other agents of disturbance, plant pathogens shape the landscapes they occupy by influences on the distribution, composition, and structure of forest trees and species dependent on those trees. In turn, distributions of these pathogens and severity of the diseases they cause are conditioned by environmental factors (such as topography, climate, and vegetation) that vary across landscapes. Because landscapes are composed of diverse, but connected ecosystems, forest planning and monitoring must occur in spatially specific context. Fortunately, new developments in remote sensing, image processing, geographic information systems (GIS), spatial statistics, and landscape ecology have greatly enhanced our ability to acquire, process, display, analyze, and interpret spatial data.

In this article, I review current literature pertaining to the concepts, applications, and methods of analysis for investigating spatial aspects of forest pathology. In particular, I identify fundamental ideas from landscape ecology and plant epidemiology, illustrate how spatial information is used, and briefly describe spatial analysis tools and procedures.

Landscape Ecology

Landscape ecology is a relatively new science concerned with patterns and processes within heterogenous areas (Forman and Godron 1986). Landscapes are characterized by their structure (number, size, shape, and arrangement of uniform patches), function (flows of energy, materials, or species), and change (temporal variation in structure and function) (Zonneveld and Forman 1991). Spatial heterogeneity is scale dependent and defined by grain (the finest level of resolution) and extent (size of area) (Wiens 1989). Because patches can be nested within patches, landscapes exhibit patterns of hierarchical structure (Allen and Star 1982). These patterns of landscape patches are influenced by ecological processes such as competition (Cale et al. 1989), stand development (Oliver and Larson 1990), and disturbance (Pickett and White 1985). Conversely, landscape pattern affects ecological processes (Turner 1989). Landscapes created by the juxtaposition of patches can be viewed as a matrix of homogenous areas with distinct edges or ecotones (Bradshaw 1992 and Holland et al. 1991). This fragmentation of the landscape has many consequences on ecosystem function (Harris 1984 and Yahner 1988).

Forest insects and pathogens are frequently recognized as disturbance agents that shape landscape patterns. Knight (1987) and Van der Kamp (1991) discuss the roles of insects and pathogens in creating vegetative diversity; Holland (1986) and Perry (1988) illustrate their roles with specific examples from the Yellowstone ecosystem and from the Pacific Northwest, respectively. Disturbance caused by fire can be interrelated with development of dwarf mistletoe (Alexander and Hawksworth 1975) or of root disease (Dickman and Cook 1989). The scale of disturbance can be assessed on at multiple levels as exemplified by Shugart and West (1977) for chestnut blight or by Tinnin et al. (1982) for dwarf mistletoe.

Plant Epidemiology

Plant diseases in natural communities cause patchiness (Burdon et al. 1989) and are controlled by environmental factors (Colhoun 1973) that vary from patch to patch. Various aspects of the epidemiological consequences of spatial heterogeneity are reviewed by Gregory (1966), Hughes (1988), Jeger (1989), Onstad and Komkven (1992), and Yang and TeBeest (1992). Early this century, Fracker (1936) recognized that increase of white pine blister rust follows a logistic increase and that the effect of the spatial distribution of *Ribes* could be quantified with the appropriate model coefficient. For different pathosystems, relevant patch sizes and important environmental factors can vary. For example, among the rusts of pine, Davis and Snow (1968) describe how synoptic weather patterns influence infection by fusiform rust; van Arsdel (1967) relates how diurnal, lake breezes affect infection by white pine blister rust; and Blenis and Bernier (1986) report on effects of forest opening size to infection by western gall rust. Hawksworth (1969) reviewed stand, climatic, site, and host factors associated with mistletoe distribution. Hunt (1983), McDonald et al. (1987), Schmidt et al. (1986), and Smith (1972), respectively, present detailed descriptions of environmental influences on white pine blister rust, Armillaria root disease, fusiform rust, and Douglas-fir dwarf mistletoe. Information on inoculum abundance, distribution of susceptible genotypes, frequency of climatic conditions favorable for infection (Webb et al. 1986) and contagion (Falk, 1989) may be expressed in the spatial pattern or arrangement of diseased trees.

Applications

Forest managers can use an understanding of the distribution patterns of forest vegetation and diseases in a variety of tasks from inventory to forest-level planning. Reich and Arvantis (1992) indicate how spatial pattern influences plot size and sample variance for better design of forest surveys. Klock et al. (1985) assert that a resource management database from multispectral imagery of the Okanogan National Forest along with GIS programs provides a current and accurate description of the forest conditions. Ripple and Luther (1987) report on a similar system for the Warm Springs Indian Reservation and illustrate its use for identifying wildlife habitat. Although GIS data can be used to generate regional rust-hazard maps (Anderson et al. 1988), Robbins et al. (1988) questions the validity of a different, geographic, rust-hazard map. McDonald et al. (1990) describe how these rust-hazard systems could be better constructed by an integration of GIS and ecosystem process models for tracking host and pathogen development. Several forest insect and pathogen models which include some kind of spatial interactions already have been written (Bloomberg 1988; Eav and Marsden 1988). Hazard and damage models can be applications within a decision support system as described by Sanders et al (1985) for the southern pine beetle. The utility of maintaining a spatial context in forest planning is demonstrated by Berry and Berry (1988) and by Hof and Joyce (1992).

Tools for Spatial Analysis

The acquisition, manipulation, analysis, and display of spatial information benefits from use of remote sensing technology, GIS programs, decision support systems, expert systems, and spatial models. Heller (1978) and Leckie (1990) review applications of remote sensing for damage assessment and forest survey.

Multispectral imagery can be used to detect mountain pine beetle damage (Gimbarzevesky et al. 1992) and vegetation stress (Reid 1987). Johnson (1990) describes applications of GIS to a variety of ecological questions. Dull et al. (1990), Morse (1986), and Rowland (1986) provide specific examples of how GIS can be used for monitoring forest pests, locating damage, and tracking insect populations. To assist managers with the volume and complexity of spatial-pest data, decision support systems have developed by the Canadian Forestry Service (Power 1988) and USDA Forest Service (Davis and White 1989). Rust (1988) illustrates an expert system for white pine blister rust. Urban et al. (1991) describe multiple scale, spatial simulation models developed from forest gap models.

Spatial Analysis Procedures

Analysis of spatial data can be conducted using a wide variety of numerical procedures. General treatments of statistical methods are provided by Cressie (1991), Cliff and Ord (1981), Pielou (1977), Ripley (1981), and Turner and Gardner (1991). Campbell and Noe (1985) review the phytopathological literature for examples of spatial analysis of soilborne pathogens (but include no examples of forest root diseases). Turner (1990) summarizes the spatial and temporal analysis of landscapes. The use of spectral analysis and fractal geometry, respectively, are described by Platt and Denman (1975) and Zeide (1991).

Spatial analysis is often conducted by examining maps. Berry (1987) provides a mathematical logic for map analysis; Haining (1981) describes how maps can be used for deductive and inductive investigations; and Bailey (1988) warns of limitations with overlay mapping. Usually, however, maps are used for display of information such as Lundquist's (1991) illustrations of disease distributions on the Black Hills National Forest.

Modeling spatial processes and including spatial relationships in non-spatial models are useful methods (Baker 1989). Spatial modeling techniques are described by Crookston and Stage (1989) for growth and yield models, by Menges and Loucks (1984) for oak wilt, Silvertown et al. (1992) for cellular automaton models of competition, and by Zack (1991) for wind field models. Wiens and Milne (1989) present a cleaver fractal model of the movements of ground beetles to illustrate how landscape scale is a relative concept. Turner et al. (1989) provide several methods for evaluating spatial models; and Rastetter et al. (1992) discuss how to scale models up from fine to course resolution.

Other methods of analysis are directed at 1) determining associations of spatially distributed elements, 2) quantifying spread, and 3) describing patterns of distribution. Alternatively, a spatial statistic may be computed as "distance" or "grouping" variable for subsequent analyses. Arriaga et al. (1988) used nearest neighbor distance, dwarf mistletoe rating, and other variables in principle components and cluster analyses. Duncan and Stewart (1991) conducted similar multivariate analyses, except they used spatial autocorrelation to determine proximity.

There are numerous examples where the occurrence or severity of forest diseases were related to geographic or environmental factors. Distributions for rusts of pine have been related to geographic location (Borders and Bailey 1986; Hoff 1992), proximity to alternate host (Gross et al. 1983), soil type (Schmidt et al. 1988), position within the crown (van der Kamp 1988). Mathiasen and Blake (1984) reviewed associations of dwarf mistletoes with habitat types; Merrill et al. (1987) considered both plant association and topography in their assessment of mistletoe distribution. Wood decay hazard was correlated with Canadian climate zones by Setliff (1986). A variety of statistical approaches have been used to explain distributions of root disease fungi. Hansen (1978) compared frequencies of incidence adjacent to and away from roads. Hobbs and Partridge (1979) constructed a vegetative ordination that approximated an elevational gradient and segregated various wood decay and root rot fungi into clusters by host and elevation. Williams and Marsden (1982) modeled root disease occurrence with a logistic screen method, and Byler et al. (1990) employed a classification and regression tree (CART) to determine disease probability by habitat type.

The spread of a forest pathogen into adjacent or distance sites can be considered as either expansion or dispersal. If the area of disease extent can be detected by remote sensing, then successive images can be compared to determine expansion as exemplified by Baker and French (1991) for dwarf mistletoe, by Cobb et al. (1982) for black stain disease, Hennon et al. (1990) for Alaska-cedar decline, and Nelson and Hartman (1975) for laminated root rot. Bruhn et al. (1991) use probit analysis to predict the success of root graft transmission of oak wilt. If the disease is not adequately portrayed by remote sensing, field mapping can be substituted as conducted by Dixon and Hawksworth (1979), Hawksworth et al. (1991), and Smith (1977). Mapping distributions or measuring dispersal distances by field examination is also useful for rusts of pine as demonstrated by Boyd (1989), Chang and Blenis (1986), Froelich and Snow

(1986), Gross et al. (1980), Kimmey and Wagener (1961), and Snow et al. (1986). Alternative methods for developing dispersal models are illustrated by Ayler (1987), Davis and Monahan (1991), Headrick and Pataky (1988), Mundt (1989), Okubo and Leven (1989), and Polymenopoulos and Long (1990).

Although there are numerous techniques for describing patterns of spatial distribution (Chellemi et al. 1988, Nicot et al. 1984, Reich and Geils 1992, and Rossi et al. 1992), there are few examples of spatial pattern analysis for forest diseases. Milgroom et al. (1991) interpret the nonrandom association of blighted chestnut trees to investigate the clonal structure of the pathogen. Reich et al. (1991) use multiresponse permutation procedures to quantify spatial patterns within dwarf mistletoe infested stands. Reich et al. (1986) use information that pines infected with fusiform rust are nonramdomly associated to correct bias in estimates of disease tree density. Bradshaw and Spies (1992) introduced the technique of wavelet analysis for investigating hierarchical spatial patterns of canopy gaps and in passing noted similarities between old-growth canopy structure and structure within root disease centers. Other examples are illustrated by Lecoustre et al. (1989) who use kriging techniques with cassava virus, Liebhold et al. (1991) who use semivariograms with gypsy moth, Nelson et al. (1992) who develop a program to conduct distance class analysis, Reyolds and Madden (1988) who apply spatio-temporal autocorrelation to leather rot of strawberry, and Weseloh (1989) who employs two-dimensional spectral analysis for gypsy moth. Additional techniques developed for studies in landscape ecology could be readily applied in forest pathology. These techniques include: Dale (1990), two-dimensional block quadrate variance analysis and Cohen et al. (1990), semivariogram analysis of canopy structure.

The large number of recent publications on spatial analysis indicate that this is an active field in both development and application. (Literature cited in this review plus additional references are included in an electronic database; an annotated bibliography is available upon request.)

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A MANAGER'S PERSPECTIVE ON SPATIAL ANALYSIS

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Abstract

Land Managers are using Spatial Analysis techniques to answer a variety of Forest Health related questions. Some of these questions come from Congress, environmental groups, the timber industry, higher levels in the Forest Service organization, the general public and Forest Service employees. Each group has a unique set of questions that demand unique answers. As the questions become more complicated, the need for Spatial Analysis tools becomes more important.

As the title implies, this is a discussion of Spatial Analysis (SA) from the land manager's perspective. The tie between this presentation and that of the other panel members is that all deal with the use of SA techniques to track certain types of spatial information to answer a unique set of questions. The questions a manager has may be different from the other panel members and the answers are usually directed at a different audience.

Most of the Forests in central and eastern Oregon are experiencing serious Forest Health problems at the current time. The reason is that the Forests contain high densities of climax species. Millions of acres are being attacked by defoliators, bark beetle, root rots, mistletoe, and impacted by seven years of drought. Mortality is as high as 100 percent. Fuel loading is already high from the previous mountain pine beetle epidemic in lodgepole pine. People are talking about fires similar to those in Yellowstone National Park. The Deschutes National Forest, like many other eastern Oregon forests, is involved with these major forest health problems and much of our energy is going into those problems.

Against this backdrop, land managers are faced with a variety of questions. Often the questions come from higher levels in the organization, such as the Regional Office, the Washington Office, and Congress. Questions also come from the timber industry, environmental groups, and the general public. Employees also have questions, and one of a manager's greatest responsibilities is to get the information, or the equipment, such as Geographic Information System (GIS) equipment, to employees so they can do their jobs.

Congress usually wants to know: How big is the problem, and where is it? For example, 110,000 acres of western spruce budworm on the Sisters Ranger District, or 150 areas of heavy dwarf mistletoe infection in ponderosa pine, across all districts. How long will it last, and what is the Forest Service doing about it? How much has been salvaged? Is the Forest going to meet its target?

The timber industry wants to know: What will be the supply of raw material? What species will be offered? What will be the amount of saw logs vs. chippable material? Should they invest in new milling or logging equipment which could cost million of dollars?

Local governments want to know: What is the forecast for timber related employment? What can they expect from the Forest Service in the form of Payment in Lieu of Taxes?

The Regional Office and Washington Office want to know many things: For example, What are the budget needs? The Forest Service does its budget planning two years in advance. This is really difficult with forest health matters because these problems tend to occur without warning. For example, the Deschutes National Forest is involved in a major thinning project in second growth stands of ponderosa pine. The entomologists

told the Forest that the stands had to be thinned or the mountain pine beetles would kill them, not two years from now, but right now. It is hard to budget for that kind of money two years ahead of time.

Last winter, the Region with the Forest's help, developed a forest health budget of nearly $100 million. Unfortunately, that was too late to get into the FY 1993 budget process, so that money will not be seen until FY 1994. To respond to that request, the Forest needed to know exactly where the problem was to determine the proper amount of recreation, wildlife, fire, timber, etc., dollars to include in the budget.

The Forest's employees also have information needs. For example, how is the problem changing over time? Is the area of defoliation getting larger or smaller? Is the amount of severe defoliation increasing or decreasing? What is it near? What are the important resource values in the area?

Forest employees have formed interdisciplinary teams that are trying to decide what to do with these forests. They are doing what we call Integrated Resource Analysis (IRA) on large, 10-20,000 acre blocks of the Forest. They are looking at all resources, recreation, wildlife, visuals, fish, range, timber, etc., and they are identifying projects for all resources, not just timber. This is an extremely complicated and costly process, and it would be totally impossible without Spatial Analysis tools.

The next group which needs information is the general public. The ability to perform silvicultural treatments to deal with forest health problems is tied very closely to the spatial arrangement of all the other resource needs in the area. It is the public that determines what will be cut or thinned, and they make their judgements based on what else is in the area. Forest health is usually not one of their priorities.

The public does, however, want to know what the Forest is doing about these forest health problems. Local land managers are convinced that they are gaining credibility with their critics and adversaries with the intensive IRA's. One important reason for this success is, the maps and the analysis they can produce with the GIS equipment can be understood by the publics.

The public also wants to know if the forests are following their forest plans. Are the forests doing what they said they would do? Are the assumptions in the plan correct? The yield tables in the Deschutes Forest Plan were state of the art. They included both mistletoe and mountain pine beetle extensions to the Prognosis Growth and Yield Model. This is great theory, but is it true? This is a new spatial analysis application, and the forest has not totally figured out how to do it yet.

Clear-cutting is another forest planning and spatial analysis issue. The forest plan discourages clear-cutting except where it is essential (about six percent of our treatment acres). The Chief of the Forest Service has also said we will reduce clear-cutting by up to 70 percent. It will be very important to know where we must clear-cut for forest health reasons, such as in stands with mistletoe infestations, and/or root rots, and then track those acres.

The forest plan also identifies the need for preserving and increasing biodiversity. The Forest needs western white pine and sugar pine for biodiversity, and there is a need to know where they will grow. The Western White Pine Blister Rust Risk Rating System provides that information. Silviculturalists on districts tend to move every few years so there is a need to store this information when is is appropriate to plan for these species.

In summary, although the questions are asked by different groups, they generally follow the same theme: where is it, how large is it, and how does it fit into the big picture? In the past our abilities to answer these questions have been poor, primarily because the spatial analysis and GIS capabilities were poor. However, so has been the level of skills in the forest health area. With a good GIS system, and good Entomologists and Pathologists to use it, the Forests should be able to predict forest health problems and correct them before they get to the epidemic stage. Hopefully, this will allow forests to focus their energies on maintaining healthy landscapes.

AN APPROACH TO CONSTRUCTING FOREST INSECT AND DISEASE RISK AND OCCURRENCE MAPS FOR GIS ON THE WARM SPRINGS INDIAN RESERVATION

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Introduction

Several years ago the Confederated Tribes of Warm Springs purchased a complete GIS system and hired two full time Systems Analysts. These employees have since been building a variety of resource information layers (36 in all). We believe that adding an insect and disease occurrence and risk layer to the existing GIS data base will better enable us to address insect and disease issues from a big picture or landscape perspective. In addition, when used together with the other layers, it will help us to look at how these agents may limit or affect other resource outputs. Thus, we believe it will be easier to evaluate the role of insects and diseases in a true integrated resource management framework.

While we can make a convincing argument in the long term for the usefulness of insects and diseases information in the data base, we are still faced with the problem of limited personnel and the up front cost of getting the information into the data base. Today I'd like to focus on the philosophy and process we are using to deal with these limitations and to get the layers built. I'll also like to share some examples with you of what we have so far.

Methods

We focused on collecting the absolute minimum information we needed for project planning. Since most of the work was done by contract we also tried to simplify actual field data collection procedures to the point where they could be clearly understood and implemented as described below:

1. **Minimize, simplify and group.** Often data collection procedures are designed by scientists, but the data is collected by seasonal field- or contract crews with very little forestry and/or insect and disease identification experience. These crews are often given a day of training and a field guide which contains many pests and no priority guidelines. As a result, they often put down obvious but non-significant pests and defects and ignore subtle, but more significant pests. To avoid confusion, we limited our field crews to collecting insect and disease data on major drivers of stand management (usually root disease and mistletoe).

   We found switching back and forth from one forest type to another in the course of a survey, usually results in confusion and inaccurate data, even from the best field crews. We are therefore compartmentalizing surveys by three general forest types (Figure 1); the pine, the mixed conifer, and, the true fir/hemlock. Not only do these forest type groupings improve the accuracy of the survey by making it easier on field crews, they also help us form a perspective on the size, cost, and scheduling of surveys needed to complete the insect and disease layers.

2. **Streamline.** We wanted to collect additional insect and disease information using *efficient*, economical procedures. We also wanted this information to be *sufficient* not only to project landscape effects, but also to select a preferred alternative (this includes the ability to run the insect and disease prognosis model extensions), and develop a general treatment diagnosis for each stand. Thus, we

chose surveys which were light and tailored to answer management questions associated with specific pest problems commonly encountered on Warm Springs.

At the time of project implementation, additional data for specific unit prescriptions can be gathered on an "as needed basis". We suspect that this additional information will not be needed most of the time.

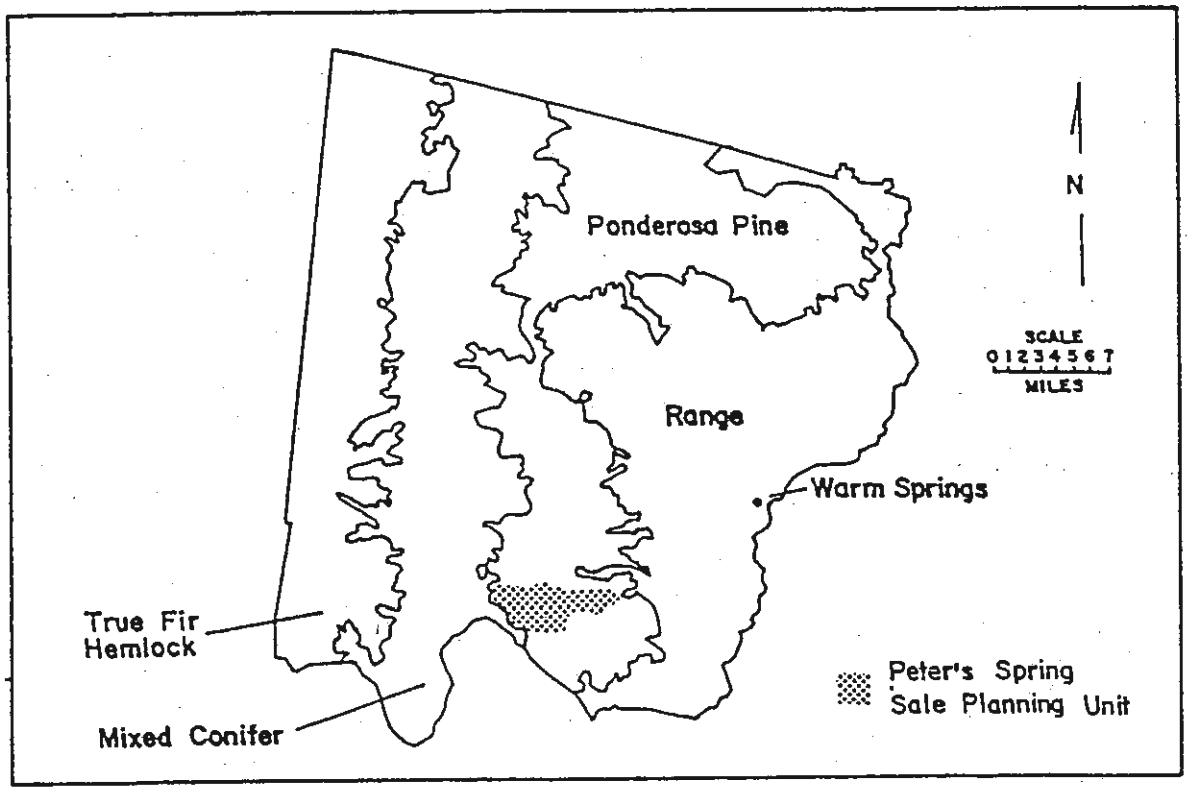

Figure 1. Forested land on the Warm Springs Indian Reservation divided into 3 general forest types: 1. The pine type (177,000 acres); 2. The mixed conifer type (152,000 acres); 3. the true fir/hemlock type (119,000 acres). Location of Peter's Spring analysis area (7,690 acres) in the pine type forest.

A specific example of the light, tailored survey described above is the dwarf mistletoe survey in the pine type. In order to develop an area based program to treat western dwarf mistletoe (*Arceuthobium campylopodum*) silviculturally, it is important to know its distribution and severity with a reasonable degree of accuracy. Hence, we have developed a method of detection call the "mistletoe reconnaissance survey". This is a light survey which provides 100% forest area coverage while collecting general information with respect to species composition, size, stand structure, dwarf mistletoe infection incidence and severity (the dwarf mistletoe rating system [DMR] [Hawksworth 1977] was used). It is a visual reconnaissance, comparable to the roadside surveys done in the Southwest and Colorado in the 1980's (Maffei et al. 1987a, b and c; Merrill et al. 1985) except survey point centers were set up on a 5 by 5 chain grid system over the entire ponderosa pine type rather than surveying only along roads. The survey method assumes a 2.5 chain (165 ft.) line of sight in all directions from the survey point center (approximately 2.5 acres).

To give you a general idea of how this survey can be used to evaluate the spatial attributes of dwarf mistletoe treatments we will use a project analysis area called Peter's Spring. A significant amount of this 7,690 acre ponderosa pine forest is infected with dwarf mistletoe (Figure 2).

By looking at the distribution of mistletoe and its severity across the analysis area we can get a general idea of the treatment possibilities over the sale area as well as develop general priorities for treatment. For example, yield simulations done in conjunction with the roadside surveys in the Southwest (Hessburg and Beatty 1985) indicate that stands with moderate to heavy mistletoe cannot be managed to rotation without severe volume loss. Thus, if wood fiber production or growing big trees is your management emphasis, your options are probably limited to regenerating the stand. In the lightly infected areas however, an intermediate treatment (thinning, overstory removal etc.) can result in full rotation with little volume loss provided the stand is treated before it progresses to more severe infection levels (Hessburg and Beatty 1985). Besides the level of mistletoe infection and management objectives, priority and specific type of treatment can depend on size of the trees and location of adjacent areas of re-infection both of which can be determined from the dwarf mistletoe layer.

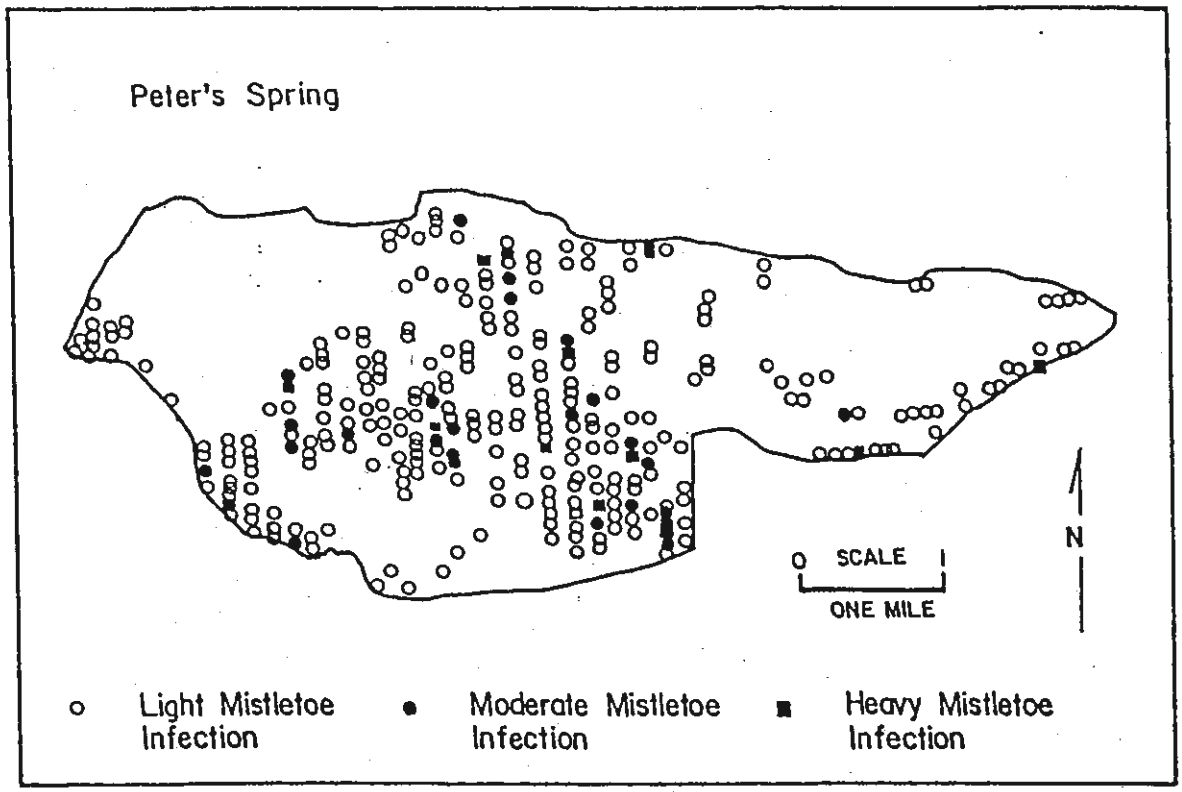

Figure 2. Western dwarf mistletoe distribution by infection severity classes on the Peter's Spring Planning Unit. The total size of the unit is 7,690 acres. Each survey point square represents 2.5 acres. In areas with no survey point squares, trees are free of dwarf mistletoe.

Integrating the mistletoe information with other resource layers such as the wildlife- and the harvest activity layer can also help with analysis and subsequent decision-making. For example, restrictions like wildlife cover requirements and maximum openings for watershed thresholds can be analyzed and considered together with the need to treat dwarf mistletoe.

3. **Use what you have.** If good information already exists (at the required level) we don't want to recollect it. Therefore, we plan to make use of any credible pre-existing pest surveys or risk maps. These can simply be added to the data base. Useful insect and disease information can also be derived from a wide variety of other sources including aerial surveys, biological evaluations and, *forest inventory efforts.*

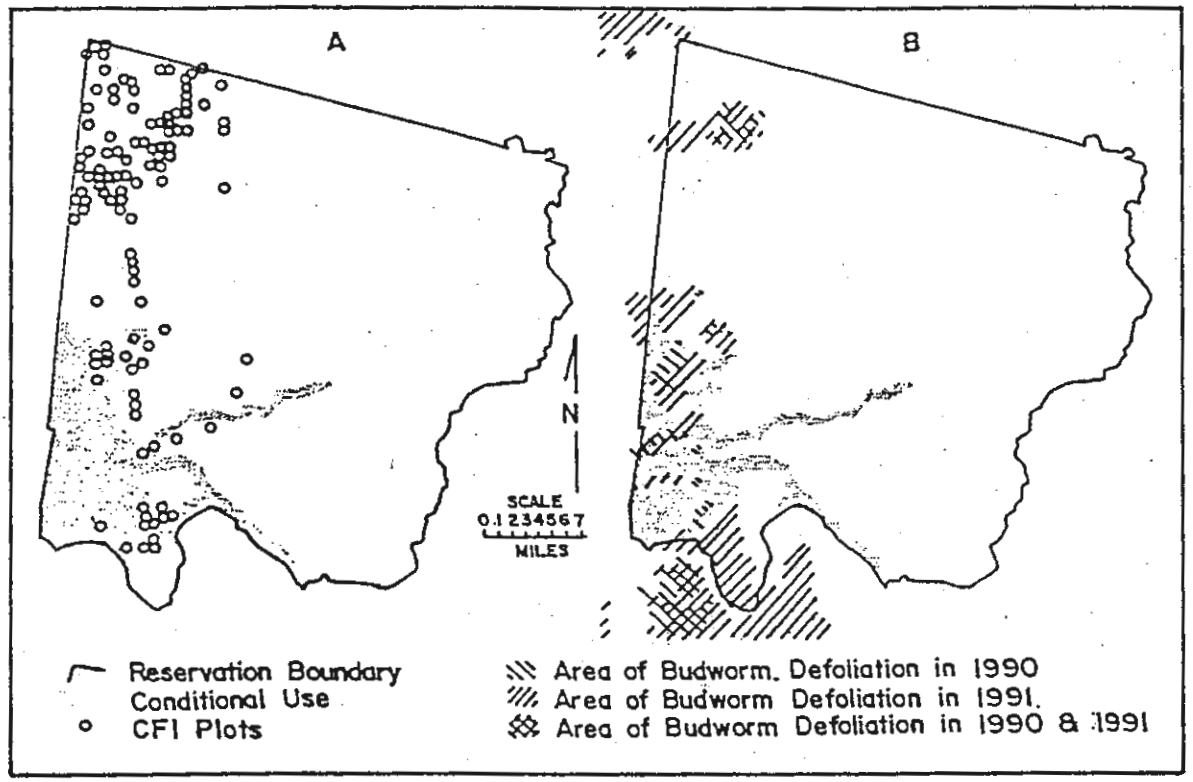

Figure 3. a. Risk map for western spruce budworm outbreaks (developed using forest inventory plots, each square denotes high outbreak risk and represents about 250 acres); b. Distribution of western spruce budworm defoliation in 1990 and 1991 according to the aerial survey maps. Conditional use areas were not covered by the forest inventory.

An example of how existing information can be used to map insect and disease risk can be seen in the mapping of western spruce budworm risk areas in the mixed conifer and fir/hemlock forest types. Since western spruce budworm (*Choristoneura occidentalis*) defoliation has been a significant and re-occurring pest on the reservation, we developed a site specific defoliator risk map. Stands composed of greater than 30% host species, with high densities and southern exposures have been found to be high risk for western

spruce budworm outbreaks on Warm Springs. These attributes are usually derived from the forest vegetation layer. Since this layer will not be installed until 1995 we are, for now, approximating the layer using the CFI (Continuous Forest Inventory) plot summary information to predict general areas of high risk to western spruce budworm (Figure 3a). Comparing the risk layer in Figure 3a to present budworm activity (derived from the last two years of aerial survey) in Figure 3b, we think areas of high risk and budworm activity correspond pretty well.

Summary

In summary, we see the GIS system complete with all resource layers, including the insect and disease maps, as essential to perform the high level of integrated resource analysis required of us. We also recognize limitations of time and resources allotted to accomplish the task. By making it as easy as possible to build the layers through economical surveys, using existing data and partitioning the work into relatively simple sub-tasks we feel it is more likely that we will end up with operational insect and disease risk and occurrence layers in the foreseeable future.

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MANAGING DWARF MISTLETOE TO ENHANCE BIOLOGICAL AND LANDSCAPE DIVERSITY

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There are several of you who could do a better job with a topic like this than myself. But I am the one who volunteered. I am not up here to advocate major changes in the way we manage dwarf mistletoes.

Yet, management of our public lands seems to be going through some major changes. Our efforts to control these parasites are affected by these changes.

In recent years dwarf mistletoe control has become increasingly controversial. Many people are saying that our treatments are too "drastic." Quite a few people are saying that dwarf mistletoe is used as *an excuse to cut timber.* (Often the truth lies somewhere between a "reason" and an "excuse".) Because dwarf mistletoes are a natural part of the forest ecosystem, some people are suggesting that we should not even try to control them. Recent research documents that dwarf mistletoe enhances bird abundance and diversity. (I might mention here that many people think that there is more dwarf mistletoe in the Southwest today than there was prior to European settlement. If this is true then we also may have unnaturally high populations of certain bird species).

I would like to tell you about some of the things we have been doing in New Mexico. Most of this applies to ponderosa pine in the Southwest, but some things may be applicable in other situations. The emphasis in my work has been at the stand level. It is at the stand level that we do treatments and affect the landscape.

One thing I've often discussed with silviculturists is that we should vary our treatments when cutting in infected areas. We create a more varied landscape when we do this. Diverse stand conditions means varied habitats which should lead to greater species diversity.

Perhaps this sounds all too simple. Because of economic pressures (taboo on "below-cost" sales and volume "targets", for example) we often don't end up with as much "diversity" as we could. Yet, with a little more imagination (and perhaps more time on the ground) we can often create more diversity in the landscape.

Infected stands in the Southwest have usually been treated with overstory removals and sanitation thinning of the understory. This may still be appropriate for some stands, but we've probably done too much of it in the past. (Too often there has been too much infection in the understory for it to work well.) I think we should do more shelterwood cuts and other types of thinning from below. I am also convinced that we should do a lot more burning along with our silvicultural treatments.

In general, I think that infected stands should not necessarily be given a higher priority for treatment than clean stands. I have several reasons for thinking this. One reason is that dwarf mistletoe is difficult to control in many situations. Conversely, there will always be some infected acreage that should be treated each year. We should concentrate on finding and treating high priority stands. More on this during the slide show.

There are many positive benefits to be gained from prudent management of dwarf mistletoes besides increased timber production. Aesthetics/visual quality is a major concern of mine, as is sustainability, when considering any project. We consider all our dwarf mistletoe control projects to be demonstration areas. We should realize that terms like Biodiversity and Forest Health represent *ideals*, which are difficult if not impossible to define.

SLIDE SHOW

GILA NATIONAL FOREST, LUNA DISTRICT

Several suppression projects during the last 10 years in Region 3 have included snag recruitment of infected overstory trees. Until recently most of this was done by mechanically girdling (chainsaw and/or axe). Mechanical girdling is relatively easy but has not always been effective. Often it has taken several years to kill the trees and some sites have experienced a lot of stem breakage.

In 1987 and 89 projects tested the effectiveness of basal fire as a recruitment method. Results so far have been encouraging. A majority of trees died within one year, and the rest within two years. Burned trees may make longer-lasting snags than mechanically girdled ones. Snags are being monitored for wildlife use. Infected overstory trees have recently been burned, or soon will be, on several Ranger Districts in New Mexico and Arizona.

LINCOLN NATIONAL FOREST, CLOUDCROFT DISTRICT

Here is an area with lots of young ponderosa pine regeneration and a sparse, heavily infected overstory. Much of the surrounding country is converting to pinyon-juniper type because of the mistletoe. Infected poles and saplings were cut and used to burn the larger trees.

The Lincoln NF and the adjacent Mescalero-Apache reservation have the most severe mistletoe problems I know about. Between 60 and 70 percent of the ponderosa pine acreage is infected. It almost seems as if the mistletoe is more "virulent" there than elsewhere. Perhaps the weather has something to do with it. These mountains in southern NM have an unusually strong monsoon and usually get more summer rain than other parts of the Southwest. When the mistletoe seeds are flying in July and August the odds are good that a lot of successful seed germination will follow.

MESCALERO-APACHE RESERVATION

We have a large suppression program on the Mescalero. Heavily infected stands are usually treated with clearcuts or shelterwoods. We have been doing some uneven-age treatments in lightly infected stands--generally those with a DMR less than 0.3 and/or less than 20% of the stems infected. Group selections are used to clean out entire infection centers, and single tree selection is done in uninfected parts of a stand, creating a mosaic.

SANTA FE NATIONAL FOREST, ESPANOLA RANGER DISTRICT

A large timber sale took place here about ten years ago. The sale area had a very high incidence of dwarf mistletoe, and most stands received overstory removals and sanitation thinning. Today a lot of the area consists of infected pole-size stands. In some areas we have found good, young (5-10 year old) regeneration and have done final removals of all the older pine. We burned several of the larger pines.

Some clearcutting and re-planting was done with the sale, but many residuals were left. Today we are cutting and burning infected residuals in those stands.

EAST-SIDE OREGON

Here we see a demonstration of what an open, "more natural" ponderosa pine forest may have looked like 100 years ago, compared with today's more typical stand conditions in the adjacent stand. These are becoming "desired future conditions" for some of our acres in the Southwest, too.

CARSON NATIONAL FOREST, EL RITO DISTRICT

This sale about 6 years ago included about 400 acres of seed-tree cuts in moderately to heavily infected stands. Understories were slashed. This project has generated a lot of concern.

SANTA FE NATIONAL FOREST, CUBA DISTRICT

More recent projects have left more seed trees/acre, as in this shelterwood cut.

CARSON NATIONAL FOREST, VALLE VIDAL UNIT

In this ongoing project, we have been mostly doing shelterwood-seed cuts. The stands are 70 to 80 years old. The Valle Vidal is primarily a wildlife area and our treatments are creating stand diversity.

With our shelterwood cuts, we plan to remove infected seed trees soon after regeneration is established. Alternately, some stands could be burned or thinned from below to keep them open and park-like.

CARSON NATIONAL FOREST, EL RITO DISTRICT (return)

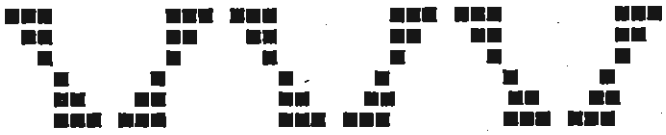
A recent timber sale has left 20-40 basal area of large pine seed trees in most stands. Like much of our high and mid elevation pine forests, the conversion to fir is at various stages. I was called in after the sale to help decide how to treat the understory. Based on "walk-throughs", we developed treatment prescriptions for over 20 stands. Here are some general thinning guidelines we came up with:

1) In stands still mostly pine, cut all visibly-infected stems and all stems within 20 feet of a visibly-infected one.

2) In stands with similar amounts of pine and fir, cut only visibly infected pine. Otherwise favor (leave) pine over fir.

3) In stands with more fir than pine, favor clean *and* lightly infected pine over fir.

We are trying to keep as much of the existing understory as we can, promote the pine, and (last but not least) control the mistletoe.



PEST EFFECTS AT THE LANDSCAPE LEVEL -- INTO THE SPACE AGE

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Abstract

Examples of landscape visualization techniques available through INFORMS-DG were presented. INFORMS-DG slides shown include: diagrams, data, models, the complete process for generating terrain scenes, and a number of examples. Scenes from a microcomputer version of the visual simulation model showed differing projected impacts of a mountain pine beetle outbreak as influenced by silvicultural treatment. A different visual simulation technique producing photo-realistic depictions of spruce beetle damage was also presented.

Good afternoon. I'm Dave Roschke and I'm a forester turned computer specialist with the Methods Application Group -- MAG for short. MAG is part of Forest Pest Management in the USDA Forest Service. We're located in Fort Collins, Colorado. I've worked with this group for a little over a year.

This is my first Forest Disease Work Conference, and also the first time I've been in Southwestern Colorado. I'm happy to be here in Durango today.

The mission of the Methods Application Group is to "develop and promote improved technology for integrated forest pest management." One of the projects I'm working on to help do this is INFORMS-DG -- the INtegrated FOrest Resource Management System on the Data General.

INFORMS is a set of automated software tools designed to assist national forest and ranger district personnel in the integrated planning and analysis of complex resource management problems and alternatives at the project level. INFORMS integrates capabilities of a geographic information system and a database management system, and uses and manipulates data to predict future environmental conditions. It is a tool that is designed and intended for use by resource specialists, rather than computer or software specialists.

Through INFORMS, a person can:

- o identify alternative actions for resource manipulation
- o assess potential impact of management actions and of natural processes
- o compare impact assessments, and
- o consistently document impact assessments and the results of the decision-making process.

Current versions of INFORMS include models to evaluate or simulate various aspects and effects of management activities, such as:

- o sediment production
- o impacts to fisheries
- o impacts to wildlife habitat
- o economic viability
- o forest pest impacts

- o timber growth and yield, and
- o visual impacts.

Today I will focus on the visual model and show some slides of some scenes generated by that model.

The Forest Service has Data General mini-computers at all 900 or so sites from the district level on up. They are all networked together. This provides all Forest Service employees with access to a homogeneous computing environment.

What I'll be showing you today was done with the Data General version of INFORMS, or with closely related software.

General description of INFORMS-DG. Spatial data consists of GIS layers, or themes. Tabular data consists of information about features on GIS layers, including the data needed to drive the growth and yield model. The model library includes several models used to analyze proposed resource management activities.

Project database. This slide illustrates how a geographic information system stores different types of data on different layers. Within INFORMS the user defines a project boundary. INFORMS creates a project database consisting of data from each layer for the area within the project boundary.

Process for visual simulation. This is the process for using the visual model in INFORMS-DG: (1) Define important viewpoints. (2) Generate terrain scene. (3) Define alternatives and place harvest units on map. (4) Run growth and yield model. (5) Generate view scene from results.

Viewshed sector diagram. From the designated viewpoint, a fan shaped area is delineated with the point to be viewed in the center. At this point INFORMS determines the area that the model will need to consider in order to develop the same scene you would see if you were standing on the viewpoint and looking toward the object point through the lens of a camera. This is referred to as the viewshed area.

Map overlays for visual. In order to generate the scene, the model will use the data from the timber stand layer and from the elevation layer that falls within the fan-shaped viewshed.

Define viewpoint. This sequence of slides will show the steps the user goes through to define a viewpoint. In this slide, a viewpoint is selected.

Define object point. This slide shows the selection of the point toward which the viewer will be looking. This point is referred to as the object point.

Line of sight. This slide shows the line of sight between the two points. Viewpoints can be ranked with respect to their relative importance.

Available maps. This slide shows the maps that are available to be plotted on the computer screen after the analysis of a typical INFORMS-DG project. Note that number 7 on the menu is "visual maps", which are the result of running the visual simulation model.

Visibility. This slide shows a map and a terrain scene. The map shows timber stands, harvest units, and the viewshed. Within the viewshed, areas that can be seen from the viewpoint are highlighted. The visible portions of the harvest units are shown in a different color. The terrain scene shows the lay of the land without vegetation, and where the harvest units fall on the terrain.

Terrain scene being drawn. This is a terrain scene in the process of being drawn. The terrain is drawn first; then the trees are plotted from the back to the front of the scene, based on stand information generated by the PROGNOSIS growth and yield model from within INFORMS-DG.

Terrain scene being drawn. The scene is nearly complete; only the immediate foreground still needs trees.

Terrain scene. This is the completed scene showing the no harvest alternative. The next two slides show the view from the same viewpoint after different harvesting alternatives have been implemented.

Terrain scene. This is the clearcut/tractor logging alternative.

Terrain scene. This is the patch clearcut/helicopter logging alternative.

Terrain scene. The next four slides show variations of the same view. In this scene the bare ground shows as brown with yellow terrain lines to give the appearance of depth.

Terrain scene. This is the same view with the same trees. The ground is colored white to simulate the appearance of snow in the openings.

Terrain scene. This is the same view, but in this scene, all of the large trees in the foreground have been removed as part of another management alternative.

Terrain scene. This is the last slide of the same view. In this scene, the overstory in the foreground has been removed, the clearcut in the middleground has been extended further back, and a mountain pine beetle attack has been simulated (with apologies to the group for having no slides showing disease effects). The red trees indicate trees that have died. Note that this scene was generated by an older version of the visual simulation model. In this version, only the left halves of the trees appear red. The intent was to simulate the effect of shadow -- the left halves of all the trees are intended to appear as if they are in the sunshine, while the right halves are in shadow. This effect was retained but diminished in later versions of the model because it doesn't look right this way. Refinements to the visual model have been made for aesthetic as well as technical reasons; we've found that this sort of visual simulation is an art as well as a science.

Lime Kiln area map. This next set of slides is related to an environmental assessment done on the Butte Ranger District of the Deerlodge National Forest in Montana. This map of the project area shows roads, harvest units, and the locations of three critical viewpoints that were analyzed for the assessment. The first is a panoramic aerial view from 100 meters above the Continental Divide. The second is a view from a different point on a road on the Continental Divide. The third is a view from a road called Roosevelt Drive.

Continental Divide aerial view. The scenes shown in the following slides were generated by a microcomputer (PC). The stand data used to generate these scenes was generated on the Data General by PROGNOSIS through INFORMS-DG, and then moved to the PC. This version of the visual model is an offshoot of the Data General version that was rewritten and enhanced for the PC by the same programmer.

This slide shows the aerial view of Alternative 5 from the environmental assessment. The intent of this alternative is to treat a high percentage of mature lodgepole pine that is susceptible to mountain pine beetle infestation while maximizing the area's contribution to the ASQ.

Continental Divide aerial view. This is the same view showing an alternative with less harvest.

Continental Divide aerial view. This is the same view showing no harvest.

Continental Divide aerial view. This is the same view showing no harvest, with a simulated mountain pine beetle infestation.

Continental Divide aerial view. This is the same view showing no harvest and the simulated mountain pine beetle infestation, but a few years later. Here the trees that were red in the previous slide now appear gray to simulate their appearance after they have dropped their needles.

Continental Divide road view. This scene shows Alternative 5 from the Continental Divide road.

Continental Divide road view. This scene shows the no harvest alternative from the Continental Divide road.

Continental Divide road view. This scene shows the no harvest alternative from the Continental Divide road, with the effects of a mountain pine beetle infestation (red trees).

Continental Divide road view. This scene shows the no harvest alternative a few years later, as seen from the Continental Divide road, with the effects of the mountain pine beetle infestation (gray trees).

Roosevelt Drive sequence. This shows the same sequence as the previous four slides from the Roosevelt Drive viewpoint.

Photographs from Roosevelt Drive. These two slides were taken from the approximate location on Roosevelt Drive that was used as the viewpoint in the previous sequence. Features in the background are clearly visible in the simulations; however in both photos there appears to be a clearly defined open notch in the timber at the back of the clearing in the foreground, which does not show in the simulations. In the process of trying to find out why, it was discovered that the area on the stand map that corresponded to the notch on the photo had been given the wrong vegetation type on the stand map. After this was corrected on the stand map, the visual model was run again and the scene was regenerated.

Roosevelt Drive revisited. This is the scene from the same viewpoint on Roosevelt Drive after the stand data was corrected. It is interesting to note that this error in the data was caught because something didn't look right in the visual simulation of the data.

Mountain pine beetle demo. This slide demonstrates a potential use of visual simulation to illustrate how management activities might affect the susceptibility of an area to pest attack, as simulated by pest modeling techniques. Three visual simulations of a hillside are shown from the same viewpoint. Each scene shows the effects of a mountain pine beetle outbreak following a different type of harvesting activity. The different types of harvest result in different post-harvest stand conditions, which affect their susceptibility to pest attack.

Spruce beetle damage simulation. The next two slides represent an entirely different level of visual simulation. This work was done by Professor Brian Orland, of the Imaging Systems Lab, Department of Landscape Architecture, University of Illinois, and Dr. Ann Lynch of the USDA Forest Service, Rocky Mountain Forest and Range Experiment Station. This slide shows a computerized digital representation of a photo of a spruce forest. A computer GIS is used by forest pest managers to predict an area of likely impact. (An outline is drawn around a stand of trees on a hillside.)

Spruce beetle damage simulation. This is the same scene, but the area outlined in the previous photo appears dead and gray. The appearance of death in these trees is simulated by applying a digital image filter to the impacted area. This technique gives a very realistic simulation of pest damage.

WORKSHOP: CALIBRATION OF THE ANNOSUS/BARK BEETLE MODEL WITH REAL DATA

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Abstract

A model simulating the epidemiology of *Heterobasidion annosum* in eastside pine and mixed conifer stands in Southeastern Oregon and Northeastern California is currently being field tested. A brief description of the model, which is linked to the Prognosis Stand Growth and Yield Model, is presented and examples of model predictions under a partial cutting prescription are discussed. In its current form the model is not providing accurate simulations of stand development in areas with Annosus root disease. Aspects of model behavior that do not agree with pathologists' observations of pathogen behavior are identified and will be corrected.

Introduction

Annosus root disease caused by *Heterobasidion annosum* (*Fomes annosus*) occurs in managed and unmanaged forests almost everywhere that coniferous forests grow. In California and Oregon, Annosus root disease impacts over 4 million acres, and can cause severe damage, particularly after commercial thinning or selective harvesting (Smith 1984). Annosus root disease is commonly associated with bark beetles, forming damaging pest complexes.

Foresters are asked to manage stands with Annosus root disease, a process that requires making long-term estimates of how the root disease will affect stand development. Silviculturists must design stand management plans that prescribe the best methods and timing for harvesting, planting, and thinning stands with Annosus root disease. Forest planners need realistic mortality and growth reduction estimates to adjust expected yields from areas with root disease as required by the Forest and Range Renewable Resources Planning Act (RPA) and the National Forest Management Act (NFMA). These laws require that scientific methods be used to determine environmental impacts of all stand management activities. A tool like the Annosus/Bark Beetle Model was needed to assist foresters in making scientifically based decisions. Once developed, other uses of the model, such as demonstrating the impacts of root disease to all levels of Forest Service management and to the public, and identifying research needs became evident.

The Annosus/Bark Beetle Model (McNamee et al. 1991) is patterned after the Western Root Disease Model (WRDM) that can be used to predict the effects of stand management in areas with *Phellinus weirii* and *Armillaria* spp. (Stage et al. 1990). To model Annosus root disease changes and additions to the WRDM were incorporated as specified by pathologists, entomologists and silviculturists with extensive experience with the disease in western forests. At a series of workshops, these experts where asked to quantify a number of assumptions for incorporation into the model. They developed parameters defining root disease dynamics (such as probability of infection, relative time to death, proportion of roots colonized after death, etc.) for eleven conifer species.

This paper summarizes the design of the Annosus/Bark Beetle Model and presents an example of model predictions under a prescription with partial cutting.

Design of the Annosus/Bark Beetle Model

The Annosus/Bark Beetle Model is currently linked to the Southeastern Oregon Northeastern California (SORNEC) variant of the Prognosis Stand Growth and Yield Model (Wycoff et al. 1982). The SORNEC variant maintains a list of sample trees which represents the inventory data for a stand at various points in time (Johnson et al. 1986). The tree list includes attributes such as species, DBH, height, etc. The Annosus/Bark Beetle Model alters these lists to account for disease development.

The model is controlled through keywords which are similar in structure to those used in the Prognosis model. There are five groups of keywords: program execution, inventory, stand management, root disease dynamics and other agents (such as bark beetles). The Annosus/Bark Beetle Model is called up by inserting root-disease keywords into the keyword sequence for a Prognosis run. A submittal system attached to the model interactively assists the user in setting up the keyword sequence (Stage et al. 1990, David and Thompson 1992, Williams-Cipriani 1992).

The prediction of Annosus root disease behavior is based upon estimates of the relative susceptibilities of trees to infection, resistance of trees to death resulting from root disease attack, disease related growth reduction, decay rate of infected root systems, and pathogen life span. Since trees weakened by root disease are influenced by bark beetles and windthrow activity, the model also simulates the interaction with these agents (Shaw et al. 1989).

These functions are done in 3 submodels: the stand interface submodel, the root disease submodel and the other agents submodel.

STAND INTERFACE SUBMODEL

The stand interface submodel computes the effects of root disease and other agents on growth, yield and mortality. It links the annosus model with the Prognosis stand growth model. To accomplish this it maintains a list of dead standing and infected stumps, computes the radial extent of tree root systems, simulates growth loss due to root disease and sets up initial stand and root disease conditions inside root disease centers. It also reconciles mortality predicted by the stand model with that predicted by the root disease and other agents submodel (McNamee et al. 1985).

THE ROOT DISEASE SUBMODEL

The root disease submodel computes root disease spread and impact on the stand. Stand conditions and management actions taken are inputs for this submodel.

Disease centers are assigned coordinates to represent their size and location. A calculation of the expansion rate and simulation of the infection dynamics inside the root disease centers is made. Since these are complex interactions, the model simulates small portions of the stand in detail, noting the relative positions of a number of trees and inoculum sources. The disease spread rate calculated in these simulations is then applied to the entire stand.

Progress of infection through roots, number of years to tree death, time for total root colonization, and life span of effective inoculum are processes used to determine disease spread. Spread into uninfested areas, disease expansion after stand entry, and carry over between rotations are also addressed by this submodel (McNamee et al. 1989).

THE OTHER AGENTS SUBMODEL

The other agents submodel computes the impact of other types of timber mortality which may alter root disease development. Other pests affect root disease development by changing host species density,

tree species composition and inoculum level, etc. Windthrow and bark beetles are the only "other agents" simulated (McNamee et al. 1985).

Special Features of the Annosus/Bark Beetle Model

To model Annosus root disease the WRDM was expanded and the following functions added: 1) borax application, 2) simultaneous simulation of the two biological species of *H. annosum* in one stand, 3) a snag count, 4) spore production and infection. Another difference between the WRDM and the Annosus/Bark Beetle model is the way root disease is carried over between rotations. The WRDM uses a "carry over" model to estimate probability of center initiation in the stand created after harvest. The Annosus/Bark Beetle Model uses a "spore model" to predict the creation of new patches following stand entries (McNamee et al. 1991).

An Example of How the Model Works

To demonstrate the model, a stand with Annosus root disease was surveyed and a prescription written to simulate old growth structure while also producing some wood products. Runs simulating partial cutting to create and maintain a stand with an old-growth appearance were run with and without root disease keywords. Since silviculturists are getting increased pressure from environmentalists and the public to use more partial cutting, we felt it would be instructive to analyze its effects on stand development for areas with Annosus root disease.

Field observation indicates that Annosus root disease will increase in stands that are repeatedly cut (Schmitt, et al. 1984). *Heterobasidion annosum* initially enters stands via airborne basidiospores that germinate on freshly cut stumps or in wounds with exposed sapwood. Spread to adjacent trees occurs via root contacts or grafts.

SURVEY METHOD

Stand characteristics and root disease conditions were inventoried in the Bird Spring Stand, a pine stand infected with P type *H. annosum*, on the Modoc National Forest, Modoc County, California. Stand exams were run with eighteen, 40 basal area factor plots taken on a 2 x 4 chain (36 x 72 m) grid following the Pacific Northwest Region (Region 6) inventory procedures (FSH 2409.21, USDA Forest Service, 1988). In the stand exam plots, presence or absence of root disease was noted after each tree or stump was checked for root disease signs or symptoms. It was also noted if the tree was within 50 ft (15 m) of a known infected stump or tree. A root disease survey was also conducted, mapping the location and size of centers within the stands. The root disease survey was done by three pathologists walking compass lines 4 chains (72 m) apart through the stand, checking trees for evidence of root disease and mapping its location.

STAND CONDITIONS -- BIRD SPRING PINE STAND

The approximately 10 acre (4 ha) stand is located approximately 2 miles (3 km) south of the Oregon border on the Doublehead Ranger District, Modoc National Forest (Modoc County, California). The stand is at approximately 5000 feet (1500 m) elevation, with a west aspect and 0-6% slope. Habitat type is ponderosa pine/wooley wyethia (Hopkins, 1979). Soils are of the Lawyer and Elmore Families (fine-loamy, mixed, mesic, pachic ultic Argixerolls) and are greater than 40 inches (100 cm) deep over soft weathered vesicular basalt (Smith, et al. 1988).

The overstory is predominantly 12 - 18" (30 - 45 cm) ponderosa pine (*Pinus ponderosa* Dougl. ex Laws.). Trees are approximately 100 years old with another cohort 60 years old. The understory is sparse with a mixture of ponderosa pine and western juniper (*Juniperus occidentalis* Hooker) present as seedlings and saplings. The site is moderately productive for ponderosa pine. Site Index at 100 years is 71.

The stand is riddled with Annosus root disease. Three of eighteen stand exam plots were located within Annosus root disease centers. Approximately 33% of the stand area is colonized by root disease. These centers are scattered throughout the stand and range in size from approximately one chain (18 m) in diameter to four chains (72 m) in diameter. Pine stumps with annosus conks were common within these centers.

Mountain pine beetle (*Dendroctonus ponderosae* Hopkins) and western dwarf mistletoe (*Arceuthobium campylopodum* Engelm. f. sp. *campylopodum*) are present throughout the site at low levels. Trees with broken tops and basal injuries are common.

Prescriptions for Annosus/Bark Beetle Model Test Runs

The following prescription was used to model partial cutting to maintain an old growth appearance. The actual keywords used to run the model are presented in Figure 1.

PARTIAL CUT/OLD GROWTH PRESCRIPTION

Goal: Manage stand primarily for old growth appearance, emphasizing vertical and species diversity. Timber yields, while desirable, are not needed to meet broader forest-wide objectives.

Thin to approximately 80 ft²/acre (18 m²/ha) BA to create a stand with the following basal area levels by size class. Do not eliminate juniper but leave best trees in all size classes.

DBH	BA/AC	TPA
>24"	50 ft²	10
18-24"	20 "	8
12-18"	8 "	6
<12"	4 "	20

Depend on natural regeneration. When stand reaches 120 ft²/ac (28 m²/ha) reassess stand objectives and repeat this cutting prescription if appropriate.

This was compared to a run with no disease development which was modeled by using the same starting inventory conditions but omitting the root disease keywords.

The root disease information was taken from the survey and entered into the model using the following description: the stand contained ten root disease centers totalling 3.3 acres in size. The center was spreading with a dynamic spread rate. The inventory was read into the model for identification of diseased trees. The event monitor, a feature of the Prognosis model that allows for treatments to be applied when certain stand conditions are met, was used to simulate the partial cutting and replanting.

Results and Discussion

A summary of stand conditions over time for the stand with and without root disease development is given in modified summary output tables from the Prognosis model (Tables 1 & 2).

After the 100 year simulation, Annosus root disease has caused a cumulative reduction in volume of 7% from a total of 31,634 merch. bd. ft. per acre (21,106 bd. ft. in the stand and 10,628 bd. ft. removed in partial cuts) for the stand without root disease activity to 29,553 merch. bd. ft. per acre (19036 bd. ft. in the stand and 10,517 removed in one partial cut) with root disease activity.

Figure 1. Keyword file used for the Bird Springs Pine Stand with root disease activity. The root disease keywords are in boldface.

```
COMMENT
          Data information for this run.
                    Stand directory file: BIRD2.EXP.DIR
                              Stand data file: 22.PROGDATA
                              The Stand ID is: 22
END
STDINFO                 509
STDIDENT                22          22
STDINFO                 509                                                         42
DESIGN                  -1          1           999.9       17          0
INVYEAR                 1990
SITECODE                10          3
BFVOLUME                                        10.0        6.0
STDIDENT
STAND       22
NUMCYCLE                10
SCREEN
IF                      20
BBA GE 120
THEN
THINDBH                 0           24.0        99.9        1.0         0.0         0.0         50
THINDBH                 0           16.0        23.9        1.0         0.0         0.0         20
THINDBH                 0           12.0        17.9        1.0         0.0         0.0         8
THINDBH                 0           0.0         11.9        1.0         0.0         0.0         4
ESTAB
PLANT                   0           10          100         100                     2
TALLYONE                4
END
ENDIF
COMMENT
PROGNOSIS VERSION NUMBER 25 WAS SELECTED
SCALE       1           2           3           4           5           6           7           8
END
ANIN
RRDOUT
RRINIT                  0           0                                   0           0           2
RRINIT                  0           10                                  0.2         3.3         1
SAREA                   10.0
RRTREIN
SPREAD                  1
SPORE                   0.9         14          1           0.9
END
PROCESS
STOP
```

It is difficult to judge whether this is a realistic volume reduction given the 33% of the stand colonized with root disease in this 100 year old stand. A group of pathologists gathered at a model workshop thought the growth reduction predicted by the model was reasonable but both overall volume estimates seem high. This may be due to overinflated yield prediction generated by the SORNEC base model.

It is a little easier to track volume in the stand over time for the diseased stand and see whether the model is responding in a sensible manner. The model predicted that the trees were growing slightly slower in the diseased run than in the "not diseased" run. The cut which is scheduled to occur when the stand reaches 120 sq. ft./acre in basal area is delayed 10 years in the diseased stand due to the increased mortality and reduced growth. This is what we would expect.

SUMMARY STATISTICS (PER ACRE OR STAND BASED ON TOTAL STAND AREA)

		START OF SIMULATION PERIOD									REMOVALS				AFTER TREATMENT					GROWTH THIS PERIOD			
YEAR	AGE	NO OF TREES	BA	SDI	CCF	TOP HT	QMD	TOTAL CU FT	MERCH CU FT	MERCH BD FT	NO OF TREES	TOTAL CU FT	MERCH CU FT	MERCH BD FT	BA	SDI	CCF	TOP HT	RES QMD	PERIOD YEARS	ACCRE PER	MORT YEAR	MAI MERCH CU FT
1990	0	157	111	192	96	70	11.4	2737	2398	11980	0	0	0	0	111	192	96	70	11.4	10	51	42	.0
2000	10	130	111	185	94	71	12.5	2824	2641	13104	0	0	0	0	111	185	94	71	12.5	10	54	7	.0
2010	20	125	125	203	104	73	13.6	3288	3180	16284	96	2201	2114	10517	39	59	31	58	15.7	10	20	6	.0
2020	30	126	42	84	33	43	7.8	1231	1220	6798	0	0	0	0	42	84	33	43	7.8	10	22	15	.0
2030	40	113	46	88	41	45	8.6	1305	1276	7234	0	0	0	0	46	88	41	45	8.6	10	28	9	.0
2040	50	108	55	102	49	48	9.7	1494	1391	7993	0	0	0	0	55	102	49	48	9.7	10	38	3	.0
2050	60	105	71	125	62	52	11.2	1840	1571	9146	0	0	0	0	71	125	62	52	11.2	10	42	3	.0
2060	70	102	88	146	74	55	12.5	2232	1896	10439	0	0	0	0	88	146	74	55	12.5	10	42	2	.0
2070	80	100	103	166	86	58	13.7	2630	2543	13178	0	0	0	0	103	166	86	58	13.7	10	42	4	.0
2080	90	98	118	184	96	60	14.8	3010	2979	16571	0	0	0	0	118	184	96	60	14.8	10	41	4	.0
2090	100	96	132	201	106	62	15.9	3380	3350	19036	0	0	0	0	132	201	106	62	15.9	0	0	0	.0

TABLE 1. Summary of results of partial cutting prescription simulated in the Bird Spring Pine Stand with annosus root disease active. The stand had 33% of its area infected with annosus root disease in 1990.

SUMMARY STATISTICS (PER ACRE OR STAND BASED ON TOTAL STAND AREA)

		START OF SIMULATION PERIOD									REMOVALS				AFTER TREATMENT					GROWTH THIS PERIOD			
YEAR	AGE	NO OF TREES	BA	SDI	CCF	TOP HT	QMD	TOTAL CU FT	MERCH CU FT	MERCH BD FT	NO OF TREES	TOTAL CU FT	MERCH CU FT	MERCH BD FT	BA	SDI	CCF	TOP HT	RES QMD	PERIOD YEARS	ACCRE PER	MORT YEAR	MAI MERCH CU FT
1990	0	157	111	192	96	70	11.4	2737	2398	11980	0	0	0	0	111	192	96	70	11.4	10	60	3	.0
2000	10	154	130	219	111	72	12.5	3309	3086	15256	124	2223	2033	9623	39	59	31	59	15.5	10	24	1	.0
2010	20	129	45	90	35	48	8.0	1314	1295	7135	0	0	0	0	45	90	35	48	8.0	10	27	2	.0
2020	30	127	54	104	47	52	8.9	1567	1541	8688	0	0	0	0	54	104	47	52	8.9	10	34	1	.0
2030	40	124	68	124	59	57	10.0	1893	1789	10279	0	0	0	0	68	124	59	57	10.0	10	42	2	.0
2040	50	122	85	148	73	61	11.3	2300	2030	11822	0	0	0	0	85	148	73	61	11.3	10	49	2	.0
2050	60	119	103	172	87	65	12.6	2772	2336	13468	0	0	0	0	103	172	87	65	12.6	10	50	3	.0
2060	70	117	121	195	100	68	13.8	3248	3023	16168	82	645	450	905	82	113	62	72	20.8	10	32	3	.0
2070	80	134	90	158	67	65	11.1	2888	2874	17292	0	0	0	0	90	158	67	65	11.1	10	31	2	.0
2080	90	132	99	170	78	68	11.8	3178	3166	19208	0	0	0	0	99	170	78	68	11.8	10	35	3	.0
2090	100	129	111	185	88	70	12.5	3499	3448	21106	0	0	0	0	111	185	88	70	12.5	0	0	0	.0

TABLE 2. Summary of results of partial cutting prescription simulation in Bird Spring Pine Stand without active root disease.

The number of centers is expected to increase after stand entry and it does, going from 10 centers initially to 100 centers, 20 years after the first removal of trees. Field observations in partially cut stands throughout California and Oregon lead pathologists to believe that the new centers would start to show up sooner than 20 years after cutting. We would expect some to show up after 10 years.

The pattern of tree mortality in the run with active root disease is unrealistic. The number of killed trees per acre (TPA) over time shows mortality starting out high, 78.5 TPA killed, then rapidly tapering off with a slight increase in the year 2030 after the first entry (See Figure 2). We would expect the actual mortality rate to start out lower with fewer trees killed per acre and remain steady or taper slightly till cutting, after which it would rise again.

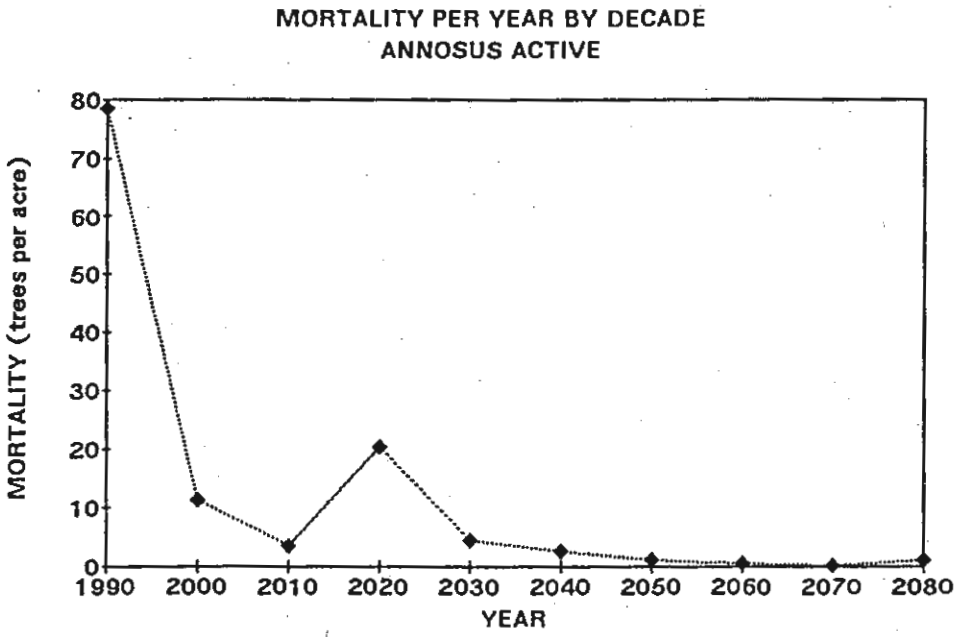

Figure 2. Pattern of mortality projected for Bird Springs. The model predicts a very high rate of mortality due to Annosus root disease at the start of the projection, which after one decade drops to a low level. The second peak in mortality rate is an increase in disease-caused mortality in response to thinning.

The discrepancies mentioned above are just a few of the differences between current model output and expected conditions. These differences between model prediction and pathologists' expectations of model behavior are being analyzed by FPM pathologists and programmers. Changes in the model will be made so model behavior matches disease behavior in actual stands. Data from Annosus root disease permanent plots are also being analyzed and the model will be calibrated so spread rate and other parameters are adjusted to local forest conditions. This verification, validation and calibration effort will continue for several years. After that time silviculturists, forest planners and pathologists will be able to more realistically assess losses and impacts due to Annosus root disease.

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BULLDOZING STUMPS AND FERTILIZING AFFECT LAMINATED ROOT ROT-CAUSED MORTALITY AND GROWTH OF PLANTED DOUGLAS-FIR

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The authors thank Mike McWilliams for presenting this paper in their absence.

Introduction

Bulldozing stumps and roots from the soil has been advocated for control of some root diseases. Bulldozing stumps from infected sites has been proposed as an option for controlling Annosus root rot in the southeast United States (Kuhlman *et al.* 1976) and has been advocated in the Pacific Northwest, using various types of equipment, to reduce laminated root rot (Smith and Waas 1983, Thies 1984, Hadfield 1985, Smith and Waas 1989), Armillaria root disease (Roth *et al.* 1977, Thies and Russell 1984), and Annosus root disease in true firs (Hadfield *et al.* 1986).

Bulldozing, at best, removes most of the inoculum from soil; residual infected roots are broken and otherwise disrupted, which may allow competing soil microorganisms to gain entrance and, under favorable circumstances, displace the pathogen. The displacement process may be accelerated by fertilization. Laboratory and field tests have shown that applying high levels of nitrogen (N) fertilizer can accelerate the replacement of *Phellinus weirii* (Murr.) Gilb., causal agent of laminated root rot, in buried inoculum by other microorganisms (Nelson 1970, 1975). However, soil displacement during bulldozing may reduce soil microbial activity (Dick *et al.*, 1988).

In 1978, we began a study to determine effects of bulldozing and fertilizing with ammonium nitrate to reduce laminated root rot and to enhance growth of planted Douglas-fir seedlings. Although it is too early in the development of the stand to project long-term impacts, by fall 1991, the disease had caused some mortality. In this paper, we report the effects of removing stumps, with a 32,000 kg crawler tractor, in combination with three application rates of ammonium nitrate and no treatment on growth and laminated root rot-caused mortality of Douglas-fir regeneration.

Methods

STUDY AREA

The study area was a 4.9 ha clearcut on a 16 percent, east-facing slope west of the crest of the Cascade Mountains near Sweet Home, Oregon (latitude 44° 21' N.; longitude 122° 39' W.); mean elevation was 285 m. Mean annual precipitation measured near the site is 127 cm (25 year average, Sweet Home Ranger District, USDA Forest Service, Sweet Home, Oregon, 97480). The soil in the study area was mapped as the Honeygrove series (clayey, mixed, mesic Typic Haplohumult), a silty clay loam derived from sedimentary and igneous colluvium (Langridge 1987). The site, site class III (McArdle *et al.* 1961), supported a 60-year-old, naturally regenerated stand (following logging) that was predominantly Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco). Western hemlock (*Tsuga heterophylla* (Raf.) Sarg.), grand fir (*Abies grandis* (Dougl.)Lindl.), western redcedar (*Thuja plicata* Donn ex D. Don), and red alder (*Alnus rubra* Bong.) comprised the remainder of the overstory. The understory was primarily salal (*Gaultheria shallon* Pursh).

PLOTS

The study area was subdivided into 30 m by 30 m units. Each unit was systematically searched twice: pre-harvest -- to locate infected standing dead or down trees or stumps that might be moved during harvest; post-harvest -- to identify infected newly-created stumps. Each *P. weirii*-infected entity (standing or down tree, or stump) was marked and the location of its stump center was mapped (Thies and Hoopes 1979). Infected stumps or down trees were selected based on the presence of stain (incipient decay) or advanced decay typical of that caused by *P. weirii* or ectotrophic mycelium typical of *P. weirii* near the root collar. An inoculum index (INOC) was calculated for each entity. The index reflected the relative infected below ground stump and root biomass based on stump diameter 15 cm above the ground, the orientation of the stump (standing or uprooted), and how long the tree associated with the stump had been dead (0 years, 0-5 years, 5-10 years, more than 10 years) based on retention of bark, twigs, and needles.

On a map depicting the locations of infected stumps, 48 points were marked as centers for 0.04 ha, circular, non-overlapping treatment plots: 40 plots were positioned to cover concentrations of infected stumps; 8 plots were positioned to cover areas without infected stumps. Each plot was a 0.02 ha, circular measurement plot centered within a 0.04 ha circular treatment plot. This resulted in a 3 m wide treated buffer around each measurement plot. All soil and seedling observations were made on the measurement plots. Each 0.02 ha data plot was rated for its inoculum potential by totaling the INOC for each stump within the data plot and adding 25% of the total INOC for stumps within the buffer. The 40 plots containing infected stumps were stratified based on total INOC into 5 blocks of 8 plots each. The range of INOC ratings within a block was reduced to a minimum by shifting some plots and thus changing their total INOC. Plot centers were established initially on the study area based on the map, stump locations within plots were later field verified. After stump removal, each plot center was reestablished and marked with a piece of steel reinforcing bar driven to ground level, as a permanent marker, and a fiberglass rod.

TREATMENTS

Treatments were applied in August, 1980, as a factorial set of combinations of bulldozing and fertilizing treatments. Two levels of bulldozing were used: B_0--no bulldozing; B_1--all stumps were removed from the plot. Each plot was bulldozed individually. Stump removal was done to remove as much of the stump and root system as possible using normal bulldozing techniques; however, no secondary effort was made to remove severed roots from the soil. A crawler tractor equipped with a brush blade on the front and a splitting wedge on the back was used. Larger stumps were first split at least once by backing into them with the wedge and then pushing out the pieces with the blade. Bulldozing was done when the soil surface was dry. Because of the dry condition of the soil, and skill of the tractor operator, little soil clung to roots. Although soil displacement was minimized, there appeared to be significant mixing of topsoil and subsoil and nearly all vegetation on the bulldozed plots was destroyed.

Ammonium nitrate, as small prills, was applied at four levels: F_0--no fertilizer applied; F_1--336 kg N ha^{-1}; F_2--672 kg N ha^{-1}; and F_3--1345 kg N ha^{-1} (0-, 300-, 600-, and 1200 pounds of N per acre respectively). The fertilizer was broadcast over a plot by using a cyclone seed spreader and crossing the plot in perpendicular directions to ensure even application. The eight possible treatment combinations of bulldozing and fertilizing (B_0F_0, B_0F_1, B_0F_2, B_0F_3, B_1F_0, B_1F_1, B_1F_2, B_1F_3) were randomly assigned within each block of eight plots. Plots were bulldozed and fertilized in late August 1980.

SEEDLING ESTABLISHMENT

Douglas-fir (2-1 bareroot seedlings) from a local seed source were planted using planting hoes in January 1981. Due to heavy browse damage the plots were interplanted in December 1983 to achieve a density of 2200 seedlings ha^{-1}. In July 1985, excess seedlings were removed from plots to leave a final density of 34 seedlings on each 0.02 ha data plot (1700 seedlings ha^{-1}). On each plot retained seedlings were selected to achieve even spacing over the entire plot (first priority) and to leave the most vigorous seedlings (second

priority). Each retained seedling was tagged, and its location was mapped. All data plots had a full complement of 34 seedlings. The plots were visited periodically to remove hardwoods, competing brush, volunteer conifer seedlings, and to record year and cause of mortality of tagged seedlings.

DATA

In July 1985, 5 growing seasons after the initial planting, the height of each seedling was recorded and in October 1989, 9 growing seasons after planting, height and diameter at breast height (dbh) were recorded. Plant cover was not measured. Prior to 1985, seedlings were observed to determine the number of live seedlings within each plot, some seedlings killed by *P. weirii* were found but other causes of mortality were not determined. After 1985, plots were visited periodically and the cause of any seedling mortality was determined, the last such observations were in October 1991.

Bulk density was measured to a depth of 20 cm using a Campbell Pacific Nuclear neutron density single-probe model (MC-1) with corrections made for soil moisture. Soil samples were collected from the upper 15 cm of soil, air dried, ground, sieved to 2 mm, and analyzed for total N using a LECO-FP-228 Nitrogen determinator.

Plot means for seedling height in 1985 and 1989, height growth from 1985 to 1989, dbh and stem volume in 1989 and mortality from 1985 to 1991 due to *P. weirii* were tested by analysis of variance. Orthogonal polynomial analysis was employed to determine the relationship between the different levels of the quantitative fertilization factor and the interaction of stump removal and the fertilization factors.

Results and Discussion

Measurements of seedling height after 5 growing seasons, seedling height and dbh after 9 growing seasons, and number of seedlings killed by *P. weirii* are summarized as plot means by treatment levels (Table 1).

Seedling mortality, due to *P. weirii*, from growing seasons 5 through 11, was less on bulldozed than on nonbulldozed plots ($p=0.019$). No significant differences in mortality were found among the various levels of fertilization, and no significant interactions were detected between fertilizing and bulldozing treatments. In July 1985, the seedling population on each data plot was reduced to 34. The roots of removed seedlings were examined for the presence of *P. weirii*, as were plot seedlings which died before July 1985. Detailed data were not collected on early seedling mortality; however, many of the seedlings examined in 1986 were infected by *P. weirii*, most of which were found on nonbulldozed plots. The mortality data reported hereafter represent only those seedlings that died between July 1985 and October 1991. During that time a total of 55 seedlings on data plots died; of those, 51 were *P. weirii*- infected. Mortality due to *P. weirii* for nonbulldozed plots in this time period averaged 5.0 percent while the average for bulldozed plots was 1.2 percent.

Fertilization of various plots resulted in increases in seedling growth as measured by dbh in 1989 ($p=0.015$), height in 1989 ($p=0.045$), height growth from 1985 to 1989 ($p=0.030$), and tree volume in 1989 calculated as $Pi*r^2*h/3$ ($p=0.002$). Fertilization levels did not result in statistically significant differences in seedling height after five seasons as measured in 1985.

Neither bulldozing alone nor the interaction of bulldozing and fertilization level resulted in statistically significant differences in any of the growth parameters. This differs from the response observed in a similar study on a gravely site near Hoodsport, Washington, in which seedling height and basal area growth after 8 seasons was significantly better on bulldozed vs. nonbulldozed plots (Thies and Nelson 1988).

Since fertilization is a quantitative factor we can examine the shape of the response curve from the lowest level (0 kg N ha^{-1}) to the highest level of application (1345 kg N ha^{-1}). The response curve indicates that the relationship between fertilization level and dbh in 1989 is quadratic in nature ($p=0.006$ linear, $p=0.067$ quadratic). This can be seen by looking at the mean dbh for each level of fertilizer (Table 1). The mean dbh

for F_0 is lowest (5.4 cm), for F_1 is higher (6.1 cm), for F_2 is still higher (6.6 cm) and for F_3 is slightly less (6.5 cm). This curve suggests to us that, diameter increases with increased fertilization up to some point (possibly around 672 kg N ha$-^1$) at which no further benefits of additional fertilization result. From our data we cannot estimate the high point on the curve. Similar response curves were found for height in 1989, height growth from 1985 to 1989, and tree volume in 1989, but not for height in 1985. We interpret the height growth data to indicate that the application of fertilizer is still having a positive effect on seedling growth 5 to 9 seasons after application. While we tested broadcast fertilization, others report that the addition of fertilizer pellets to planting holes before planting Douglas-fir give mixed results on good sites (Austin and Strand 1960, Arnott and Brett 1973), but increase height growth for at least 5 years on poorer sites (Rothacher and Franklin 1964). Broadcast fertilization of 225 kg N ha$-^1$ is practiced in some Pacific coast stands of young to middle-age Douglas-fir (Bengtson 1979, Tappeiner *et al.* 1986). Although duration of response will differ based on many factors, growth response gradually approaches zero within 10 to 15 years after treatment (Miller and Fight 1979). Further observation of the seedlings in this study may add to our understanding of the duration of growth response when seedlings are fertilized.

Table 1. Mean height, diameter breast high (dbh), and *Phellinus weirii*-caused mortality of Douglas-fir seedlings on plots treated by stump removal and fertilization in August 1980, and planted in January 1981.[1]

	plots	*height*	*height*	*dbh*	*dead*[2]
		(cm)	*(cm)*	*(cm)*	
Treatment[3]	*n*	*7/85*	*9/89*	*9/89*	*10/91*
Bulldozing					
B_0	24	213	528	6.0	41
B_1	24	214	549	6.3	10
Fertilizing					
F_0	12	195	489	5.4	2
F_1	12	218	546	6.1	22
F_2	12	223	561	6.6	11
F_3	12	225	559	6.5	16

1 Each combination of stump removal (bulldozing) and level of fertilization was applied to one randomly selected plot within a block. Plots were blocked based on the relative amount of inoculum (inoculum index) on a plot.

2 Total *Phellinus weirii*-killed seedlings by treatment level. Bulldozing treatments each contained 816 seedlings. Fertilizing treatments each contained 408 seedlings. Despite the large apparent differences, the percent mortality on fertilized plots was not significantly ($p < 0.05$) different from the percent mortality on non-fertilized plots.

3 Because no statistically significant ($p < 0.05$) interactions between combinations of bulldozing and fertilization treatments occurred, the results are presented as means of all plots receiving a given treatment: B_0=no stump removal activity; B_1=all stumps removed from the plot; F_0=not fertilized; F_1=fertilized (336 kg N ha$-$1); F_2=fertilized (672 kg N ha$-$1); and F_3=fertilized (1345 kg N ha$-$1).

Blocking plots based on the inoculum index reduced variation and increased sensitivity. We anticipated seedling mortality and seedling growth would be sensitive to inoculum but that the soil factors would not.

Our data support those hypotheses. Since replication mean square exceeded error mean square for the growth and mortality responses, we concluded that blocking was an effective means of reducing variation.

Although it is still early in the development of the study stand we feel that there are two conclusions from this study which may impact stand management decisions: 1. Bulldozing *P. weirii*-infected stumps reduces laminated root rot-caused mortality during the first 10 years of stand establishment. 2. Preplant broadcast fertilization with ammonium nitrate increased the growth of Douglas-fir seedlings.

Additional Information

The study described in this paper is duplicated on study areas near Apiary, Or; Gates, Or; and Hoodsport, Wa. Summary data for these areas is presented in Table 2, although the data should be considered preliminary it is presented here to be available for comparison. On inspection the trends are similar.

Table 2. Preliminary data: mean height and *Phellinus weirii*-caused mortality of Douglas-fir seedlings on four study areas treated by stump removal and fertilization.

Mean Height and *Phellinus*-caused Mortality

				Mortality(%)				Height (cm)			
Study Area	*Planted*	*tagged*	*Age*	*B0*	*B1*	*F0*	*F1*	*B0*	*B1*	*F0*	*F1*
Sweethome, OR	2/81	7/85	9	5.0	1.2	0.5	5.4	520	549	489	546
Hoodsport, WA	3/78	9/81	11	11.2	2.2	6.2	7.4	426	531	444	438
Apiary, OR	2/79	10/84	11	3.8	0.5	2.9	1.5	471	501	453	486
Gates, OR	2/81	7/85	9	2.7	0.2	2.9	1.0	438	474	450	471

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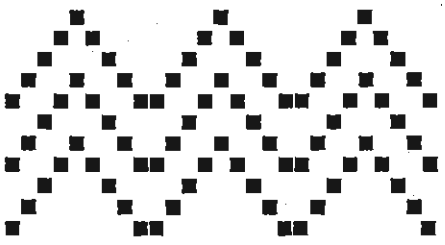

FOREST HEALTH MONITORING: STATUS OF IMPLEMENTATION IN CALIFORNIA AND COLORADO

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Interagency (USDA Forest Service [USFS], Environmental Protection Agency - Environmental Monitoring Assessment Program [EMAP], and State Forest Service) implementation of Forest Health Monitoring (FHM) is under way on approximately 280 forested plots in California (CA) and approximately 160 forested plots in Colorado (CO). Funding levels have required statisticians to develop a one quarter interpenetrating design from the base number of national grid hexagonal plots in each state. These plots are evenly distributed, as a triangular grid subsample of the entire grid of plots, across the forested portions of CA and CO. This design allows full coverage of each state on an annual basis while measuring only one fourth of the total plots. In 1992, CA and CO will measure approximately 70 plots and 40 plots, respectively. Every fifth year these plots will be visited for remeasurements.

Based on 1991 pilot study results from CA and CO, measurements are being taken for mensuration; crown classification; damage and mortality; photosynthetically active radiation (PAR); soils; stemwood and dendrochronology; vegetation structure; air pollution bioindicator plants; lichens; global positioning; and off-subplot mortality survey. Three of these measurements are considered to be implemented on the subplots: mensuration, crown classification and damage and mortality. Other measurements are being referred to as demonstration or pilot variables and may be ready for full implementation in the future. All measurements are taken on four 1/24th acre subplots (Fig. 1). Region-2 (R-2) Forest Pest Management (FPM) in cooperation with Pacific Northwest (PNW) Forest Inventory and Assessment (FIA) is conducting a pilot mortality survey from the off-subplot area on the one hectare plot (Fig. 1). FPM is also working with the Methods Application Group (MAG) from Fort Collins in conducting aerial photography and interpretation of all 1992 plots to enhance the ground survey information.

CA and CO field crews attended training sessions June 1-12 before entering the field. One week in Logan, Utah was spent on intensive training on methods required for each variable to be measured. The second week involved training on reconnaissance; plot location; safety; and local training on specific tree species, vegetation, and insects and diseases in CO and CA. June 15 was the first day of field implementation.

Plots are being established and measured by a variety of personnel from different cooperating agencies. There are two five-person crews in CA and two seven-person crews in CO. In CO each crew is made up of:

Subplots -

- Forester - FIA (USFS - Intermountain Station)
- Forester - FPM (USFS - Region 2)
- Botanist - National Forest Systems (USFS - Region 2)
- Soil scientist - Soil Conservation Service ($ by EMAP)
- Logistician - Bureau of Land Management ($ by EMAP)

Off-subplot mortality survey -
Pest Specialist - FPM (USFS - Region 2)
Pest Specialist - Insect and Disease (CSFS)

CA only has the subplot crews with personnel and funding provided by a different mix of agencies.

In CO the foresters are taking mensuration, crown classification, damage and mortality, air pollution bioindicator plant and stemwood measurements. The botanist is responsible for vegetation structure, lichens and PAR. Soil characterization is being done by the soil scientist. Global positioning and mortality survey data is being measured by the off-subplot crew. Logistics personnel are taking care of lodging reservations, computer downloading, computer maintenance, sample maintenance, sample records, sample mailings, and acting as field backups for the foresters.

At the training session in Logan, CO's off-plot mortality crews were cross-trained for different variables. To increase efficiency in the field the areas of cross-training were lichens, air pollution indicator plants, PAR, vegetation structure, and VCR. This allows the crews to cover for sick days, unexpected emergencies or other needed leave time. It also makes for shorter days in the field. CO crews are averaging about ten hour days in the field. Last year they averaged over twelve hour days with more accessible plots.

Currently CO crews are averaging completion of 2 - 2 1/2 plots per week, as predicted. They have completed 20 plots. Debriefing is scheduled for the week of August 17. By that time all plots will be completed and field audits of both crews will be done.

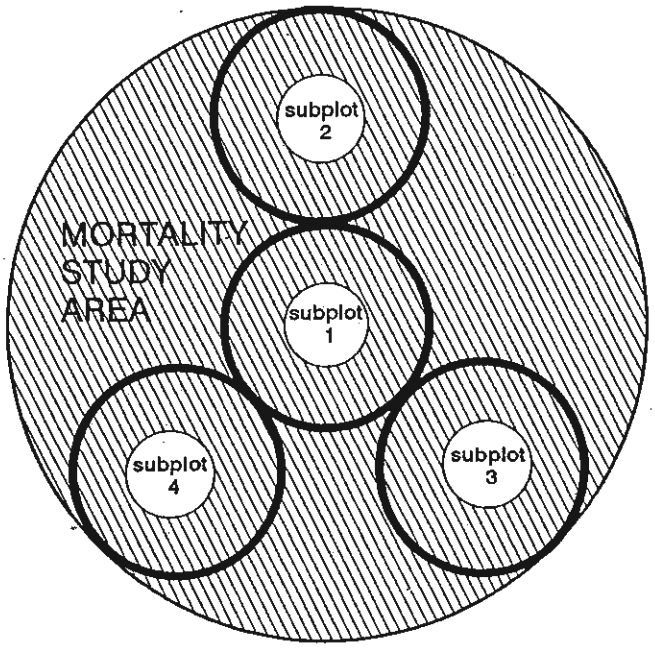

FIGURE 1

Figure 1. Layout of subplots within the one hectare plot. All measurements were taken in 1/24 hectare subplots. A pilot mortality survey was done in the one hectare area surrounding the subplots.

TECHNIQUES TO QUANTIFY RELATIONSHIPS BETWEEN ROOT SYSTEM FUNCTIONALITY AND VIGOR OF SOUTHWESTERN CONIFERS INFECTED WITH *ARMILLARIA* SP.

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Introduction

Armillaria spp. is a prominent killer of coniferous trees in forests throughout the world. In drier interior regions of the western U.S., *Armillaria ostoyae* (Romagnesi) Herink frequently acts as an aggressive pathogen on pines (*Pinus* spp.), true firs (*Abies* spp.), and Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco) (Shaw and Kile 1991; Wargo and Shaw 1985).

Various methods have been used to sample roots on infected trees (Alexander 1989; Baker et al. 1992; Zeglan and Baker 1990), but little information exists on the relative longevity, or "time to death", of conifers infected by *Armillaria* sp.

Our premise is that the systems foresters use to rate trees for susceptibility to attack by bark beetles (Keen 1943; Roe 1948; Thomson 1940) are actually driven by root disease. We are attempting to formulate a hazard rating system by characterizing root disease status in variously sized ponderosa pine (*Pinus ponderosa* Dougl. ex Laws.), white fir (*Abies concolor* (Gord. & Gled.) Lindl. ex Hildebr.) and Douglas-fir in comparison to crown condition and other measurements of tree vigor. This paper introduces the techniques we are using to assess root functionality and tree vigor. We also discuss three techniques we employed to remove root systems.

Materials and Methods

About 200 trees in south-central Colorado and northern New Mexico were assessed for root system functionality and above-ground "vigor". We excavated 39 white fir, 39 Douglas-fir and 10 ponderosa pine on the Archuleta Mesa in southcentral Colorado in the summer of 1991. The study area was relatively flat, approximately 9150 feet in elevation, and an *Abies concolor/Vaccinium myrtillus* habitat type.

In the winter of 1991 we harvested 90 ponderosa pine of various sizes and ages on the Jemez district of the Sante Fe National Forest. This site is at an elevation of 8500 feet and has gently rolling topography and a *Pinus ponderosa/Festuce arizonica* habitat type. Armillaria root disease and southwestern dwarf mistletoe (*Arceuthobium vaginatum* var. *cryptopodium* (Engelm.) Hawksworth and Wiens are the two major diseases in the area. Soils are of volcanic origin and have a high pumice content.

Prior to harvesting, each tree was given a Root Rot Rating (Stage et al. 1990) based on the presence or absence of above-ground symptoms and each tree's relative proximity to root disease infected trees or stumps. Shigometer readings were taken at 1.4 m. at each cardinal direction (Piene et al. 1984) and trees were rated for intensity of dwarf mistletoe infection (Hawksworth 1977).

Pines were given a Thomson Vigor Rating (Thomson 1940); firs were classified by Roe's rating scheme (Roe 1948) and a scheme that W. Thies (personal communication) developed for use on fumigated trees infected with *Phellinus weirii* (Murr.) Gilb.

Some of the vigor characteristics we assessed include crown position, terminal growth of upper branches, quantity of dead branches, crown density (Belanger and Anderson 1987), needle color, needle retention, height, DBH, crown ratio and bark thickness. Finally, wood and foliar samples were collected for carbohydrate and nutrient analysis.

Following all above-ground measurements, root systems were extracted and their functionality assessed. On the Archuleta Mesa, root systems were extracted by a bulldozer and remaining soil removed with hand tools. While trees were still standing, the bulldozer, with its blade set at approximately breast height, would approach and "kiss" the tree. The bulldozer would then slowly increase the force exerted on the tree and when enough force was exerted the tree would fall over, exposing most of the root system. The bulldozer then backed up, lowered its blade into the soil, and lifted as much of the root system as possible. A sawyer then cut the root system from the stem and adhering soil was removed with hand tools. We attempted to use water under high pressure to remove soil from roots. However, this method was soon abandoned because it was not effective with heavy clay soils and a large quantity of water required.

On the Jemez District, we used a backhoe excavator and a "vibro-stump puller" (Arnold 1981) to remove ponderosa pine stumps. A John Deere 680 excavator with a 24 inch bucket was used to remove stumps less than 24 inches in diameter. The operator positioned the bucket's teeth against the stump base and applied pressure, pulling the stump toward the excavator. Slack in the excavator arm allowed the operator to "jiggle" the stump up and out of the ground. When roots on the far side of the stump were either loosened or broken, and the stump thus became partially excavated, the operator released bucket pressure on the stump and maneuvered the bucket into a position underneath the partially excavated root system. An upward force was then applied to the stump and remaining roots were dislodged from the soil. All remaining broken roots over 2 inches in diameter were removed from the soil by pulling with a chain attached to the excavator.

A vibro stump puller (Foster Inc., Houston Tx.) was used to extract stumps greater than 24 inches in diameter at the ground line. This machine consisted of hydraulic grapples, which attached to stumps, and a heavy-duty vibrator, which would vibrate at ca. 1,600 revolutions per minute. The vibrator weighed about 5,400 pounds and was powered by a 3 ton generator which was carried by the excavator. The vibro puller was attached by cable to the bucket of a rubber-tired front-end loader with a 27 cubic yard bucket. The operator of the front-end loader would hang the vibro puller above a stump, lower the vibrator, set the grapple prongs around the stump, and start the vibrator. After 4 to 25 minutes, the front-end loader could lift the root mass out of the ground. The vibrations removed nearly all soil and debris from roots, resulting in very little manual cleaning and limited breakage of roots. The pumice soil was very conducive to cleaning roots of what little soil remained.

To assess the functionality of root systems, all lateral roots (greater than 0.5 inches diameter) exiting the root collar region were measured for diameter and converted to cross sectional areas. Added together, their sum was the total, potentially functional, cross sectional area of the root system. A root was considered functional if there was no evidence of hindrance to the transport of water in the xylem and sugars in the phloem, either proximally or distally. In other words, integrity of cambium, phloem and xylem had to be intact (i.e., no discoloration or presence of mycelia) for a root to be classified as fully functional. With a hand ax we removed bark from all roots and looked for any discoloration or disruption of phloem or xylem, and symptoms or signs of pathogens such as *Armillaria* spp. or *Heterobasidion annosum* (Fr.) Bref.

Our assessment of functionality began at the root collar and proceeded distally along each lateral root. At each root fork we determined the relative contribution to functionality of each lower order lateral (cross sectional area of each lower order lateral as a proportion of the total cross sectional area of all laterals exiting from the fork). We proceeded accordingly through all forks of lower order laterals until roots were dead, alive at 0.5 inches diameter, or broken off. For broken roots, diameter and length measurements were taken to estimate the percentage of root biomass remaining in the ground.

Results

To test extraction efficiency we will compare amounts of biomass extracted by the various machines to the total projected biomass for a given root system. The vibro stump puller has apparent advantages over the other machines employed. Although it requires a large excavator to move it about, the residual stand received relatively little damage, soil disturbance is minimized, and a "soil-free stump" is extracted that may have use for chip or energy production. The vibro stump puller was very efficient at extracting stumps greater than 20 inches in diameter and was able to extract stumps up to 47 inches in diameter.

We are proceeding with the analysis of vigor and root functionality to see if we can derive a hazard rating system for conifers infected by *Armillaria* spp. We plan to report on this information at a future WIFDWC.

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ANNOSUS ROOT DISEASE IN CENTRAL IDAHO

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Annosus root disease (*Heterobasidion annosum* (Fr.) Bref.) is causing notable conifer mortality in grand fir habitat types in central Idaho. The most significant mortality is occurring in Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco.) trees of all age classes. A project looking at some aspects of the general biology of *H. annosum* in central Idaho has been completed. Study sites were selected on the Elk City and Clearwater Ranger Districts of the Nez Perce National Forest, Idaho. The specific objectives of the study were: 1) characterize the population structure of *H. annosum* on three sites with grand fir habitat types on the Nez Perce National Forest, including identifying the intersterility group(s) present; 2) determine if the relative incidence of the disease on these three sites has significantly increased with clearcutting; and 3) determine if the relative incidence of *H. annosum* varies between species of trees, and between sizes of trees and stumps on these three sites. Three pairs of stands in the grand fir habitat series were intensively examined during the summers of 1990 and 1991. Each pair consisted of a 10 to 30 year old clearcut and an adjacent 80+ year old uncut stand.

Basic stand data were collected from 1/50th acre plots. These plots were then rated for root disease severity using the following guidelines: 0 = no evidence of root disease; 1 = *H. annosum* fruiting bodies and/or decay present; and 2 = symptomatic trees present. Plots from each of these ratings were then selected for intensive sampling.

Intensive sampling was done on 1/20th acre plots. Samples were collected using three techniques: 1) stumps were sawed to ground level and wood samples and/or *H. annosum* fruiting bodies were collected; 2) trees 5 inches dbh or larger were drilled above two major roots with a gas powered drill and the resultant chips were collected; and 3) trees less than 5 inches dbh were excavated and two roots were collected. All isolations were placed on a selective medium for *H. annosum*.

Vegetative compatibility (vc) plate pairings between isolates were used to describe the vc groups of *H. annosum* in the study areas. All possible pairings within stands were performed, as well as all possible pairings between adjacent stands. Forty-one vc groups were identified with this plate pairing method. Thirty-three were unique, represented by single isolates. The other 20 isolates fit into 8 multiple isolate vc groups. Isozymes from seven enzyme systems were then used to discern differences within multiple isolate vc groups in order to identify possible clonal groups. Four of the eight multiple isolate vc groups had identical banding patterns within each vc group, so were considered clones. Two other multiple isolate vc groups came from the same tree, so were assumed to be clones, although the isozyme work was incomplete. The last two multiple isolate vc groups were separated by a great distance, and proved to have different isozyme banding patterns, and were thus determined to be separate individuals. The largest distance between isolates from the same clone was approximately 136 meters.

The intersterility group(s) of all collected isolates were identified by examining selected enzyme systems. All isolates belong to the "S" intersterility group.

The most noteworthy conclusions from the incidence work done in this study are as follows: clearcutting stands in the grand fir series habitat types without treating stumps significantly increases the frequency of *H. annosum*; uncut stands in the grand fir habitat type series are infected with *H. annosum*, although at relatively low frequencies; and Douglas-fir and grand fir (*Abies grandis* (Dougl.) Lindl.) have very similar disease incidence rates and are likely very similar in their susceptibility to infection by *H. annosum*.

The following additional conclusions have been made: 1) Spore infections are apparently the major means of introduction of Annosus root disease into these uncut and clearcut stands. Vegetative spread is secondary in importance; and 2) *H. annosum* is rarely the only root disease present in stands in the grand fir series habitat types in central Idaho. It is often found in combination with other root pathogens including *Armillaria* sp., *Phaeolus schweinitzii* ((Fr.) Pat.), and *Perenniporia subacida* ((Pk.) Donk).

THE INTRODUCTION OF THE EURASIAN POPLAR LEAF RUST FUNGUS *MELAMPSORA LARICI-POPULINA*, INTO NORTH AMERICA DURING AN EPIDEMIC OF *M. MEDUSAE* ALONG THE LOWER COLUMBIA RIVER

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Abstract

Melampsora medusae caused an epidemic of leaf rust of hybrid poplar (*Populus trichocarpa* x *P. deltoides*) along the lower Columbia River in the fall of 1991. Although native to North America, *M. medusae* had not previously attacked hybrid poplar in the Pacific Northwest. The initial disease focus was a commercial plantation of 11 clones planted in monoclonal blocks of 5 to 50 ha, near Scappoose, OR. By early fall, 6 hybrid clones infected by *M. medusae* received a Schreiner rust severity rating of 100 and were partially defoliated. Four other clones were moderately rusted (rating of 25 to 50) and showed no premature leaf abscission. One clone was only slightly rusted (rating of 0 to 25). Two monouredinal isolates (one from Woodburn, OR and the other from Goble, OR) and a Kentucky isolate of *M. medusae* f. sp. *deltoidae* were tested for poplar host range on detached leaves in the laboratory. The Kentucky isolate was distinguished from the Oregon isolates on one clone of *P. deltoides*, three hybrid clones, and two clones of *P. tremuloides*.

Melampsora larici-populina, native to Eurasia, was also found in late autumn 1991 in hybrid poplar plantations along the lower Columbia River. The telial (poplar) host range of three different monouredinial isolates (one from Woodland and two from Scappoose) was also investigated in the laboratory with detached-leaf inoculations. Clones known to be susceptible in Europe and Australia to *M. larici-populina* (*P. nigra* cv. italica and *P.* x *euramericana* cv. I-488) were susceptible. *P. trichocarpa*, the native black cottonwood of the Pacific Northwest, appears to be uniformly susceptible (20/20 clones tested) to *M. larici-populina*. Variability in the frequency of resistant clones was found in other poplar taxa including interspecific hybrid classes.

DISEASES OF RED ALDER

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Red alder is relatively free from most disease problems. Many fungi have been reported growing in association with red alder (Shaw 1973, Lowe 1969, Farr, et al. 1989), but few have been shown to cause economically important levels of damage in natural stands. Several stem canker-causing pathogens, *Didymosphaeria oregonensis*, *Hymenochaete agglutinans*, and species of *Nectria* cause some damage, especially in young stands, but overall their impact is slight. However, these organisms may become more important in nurseries and young managed stands. The use of such weak pathogens has also shown some promise as biocontrol agents in the control of juvenile red alder (Dorworth 1992). Fungal diseases of alder catkins have also been reported (Mix 1949), i.e. *Taphrina occIndentalis* and *T. alni* cause enlargements of the bracts of female catkins. Again, these fungi are not currently economically important, but could become so if alder seed production is pursued.

Compared with other hardwood species, living red alder trees have very little decay (Figure 1). In our work currently under way in British Columbia, we examined 383 alder trees on Vancouver Island, ranging in age from 20-120 years old. Trees were dissected, and assessed for decay volume and the relation of decay columns to externally visible pathological indicators. Decay losses of merchantable volume were less than 4% in all trees sampled. (This value is an overestimation, since half of the sample trees were chosen because they had pathological indicators and were more likely to have decay.) Although the incidence of decay was found to increase with age, the number of "decay events" showed little variability among age classes (Table 1). The median volume of decay was 0.0024 m^3, with decay volumes ranging from 0.00001 - 1.1 m^3. Decay volume was poorly correlated with tree age; decay columns in trees of all ages were usually of low volume, although high decay volumes were associated with older trees. Susceptibility to decay in older trees does not appear to be as severe as suggested in previous reports (Johnson, et al. 1926, Worthington 1957). For example, trees harvested at 60-80 years would have predicted decay losses under 3.5%.

Incidence of Decay by Age

Age Class	% Trees with Decay	Decay Events per Tree
15-24	18.8	1.7
25-34	24.1	1.3
35-44	35.0	1.4
45-54	50.4	1.5
55-64	65.0	1.4
65-74	63.6	1.4
75+	*93.8*	*1.7*

Table 1. The incidence of decay in red alder increased with age, although the number of "decay events" showed little variability among age classes.

A total of 243 decay events were observed in the sample trees. Much of the decay present in living alder resulted from injury to standing trees due to scars from falling trees or branches, or from broken

tops (which remain broken or form forks or crooks) (Table 2). Such damage occurs naturally, through the effects of ice and wind storms, or came from injuries sustained during logging operations. Once trees are injured, decay organisms gain entry through the damaged tissue. However, alder is very efficient in its ability to compartmentalize decay, and most decay events do not spread much beyond the injured tissue. For example, the dead tissue of stubs formed from self-pruned branches was colonized by fungi, and sometimes developed into a decay column in the main stem. Most branch stubs, however, were overgrown by healthy wood with no further decay development.

Occurrence of Decay Associated with Pathological Indicators

Pathological Indicator	Occurrence of decay
Scars	36%
Forks	13%
Crooks	9%
Branches	12%
Dead Tops	6%
Other	2%
Unknown[1]	22%
Total	100%

[1]During dissection, it was sometimes impossible to trace decay to a recognized pathological indicator. In such cases, a designation of "unknown" was assigned. These decay events are likely associated with branches or scars.

Table 2. Much of the decay present in living alder was associated with injuries caused by falling trees or branches, or with broken tops.

A number of decay fungi have been isolated from living alder trees in British Columbia, including *Sistrotrema brinkmannii*, *Pholiota adiposa*, *Trametes* sp., *Meruliopsis corium*, *Heterobasidion annosum*, and *Armillaria sinapina*. A previous report suggested that white heart rot, caused by *Phellinus ignarius*, is the most destructive disease of living alder trees (Worthington 1957, Hepting 1971). These statements seem to have originated from Johnson and coworkers (1926) who made a similar claim, unsupported by data or reference citation. *P. igniarius* has been found only rarely on living red alder in British Columbia, although the pathogen may be more common in other parts of the alder range.

Wood stain and decay do proceed quite rapidly in cut alder trees. For this reason, logs should be processed as soon as possible after harvest, particularly in warm summer months. The development of stain and decay is retarded in winter months and in logs stored in fresh water (Worthington, et al. 1962). The dynamics of harvested alder log degradation, including decay rates and fungal interactions is currently under study in British Columbia.

Disease problems will likely increase as the management of alder is intensified. Problems can be anticipated in nurseries and plantations, and when alder is planted in offsite locations.

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DISEASE AND INSECT PROBLEMS OF RED ALDER: OBSERVATIONS IN YOUNG PLANTATIONS

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Historically, disease and insect problems of red alder have received little attention. Contributions of pathologists and entomologists to the proceedings of red alder management symposia have included discussions of damage that may result from insect or fungal attack. The lists of potential pathogens and damaging insects tend to be lengthy. Observations and information based on field collections or past outbreaks that are long on description and short on management implications often form the basis for these lists. The organisms were sorted into groups of damage types-the defoliating insects, the bark beetles, the canker-causing fungi, the stem decays- and the investigations stopped there. We know very little about the circumstances in which these agents are damaging or what constitutes an economic threshold for damage in a species that we have only recently begun to manage.

Damage is occurring in some of our alder plantings. Specifically, we have observed tree mortality, topkill, crown thinning and chlorosis. Incidence of damage has varied greatly from site to site, ranging from a few individual trees representing a trace of planted stock to 5-10% of planted trees affected to some degree in a large plantation. Patterns of damage also vary. Mortality in some areas is scattered and in other locations tends to be grouped in small pockets. We have observed situations where naturally seeded alder is affected along with planted stock.

Our observations have all been made in alder plantings prescribed to sanitize sites of *Phellinus weirii*, the cause of laminated root rot. Some of these are among the earliest red alder plantings made in the Pacific Northwest. For example, one of the plantings in the Oregon coast range is currently 9 years old. Performance of trees has been quite variable. Frost damage eliminated an entire spacing study. Throughout the plantation there are patches of vigorous trees and patches of trees with significant height growth reduction, reduced leaf area, chlorosis, and mortality. Brush competition is significant. Damage tends to occur in areas of convex topography and heavy salal.

The types of insects and fungi found in association with this and damage occurring in other locations would support the idea of how important the evaluation of stock and site is. Much of the topkill and tree mortality is due to stem and basal cankers. The causal agents in these situations are yet unidentified. Those fungi that are known to cause this type of damage in red alder are often opportunists. They have a reputation of attacking plants stressed by other agents or environmental conditions. They may cause branch dieback. The fungi may invade main stems and kill enough tissue to effectively girdle the tree. If cankers occur at the base of a tree, the damage will be observed as whole tree mortality. If cankering occurs elsewhere on the stem, topkill will be observed. Early stages of infection are chlorosis and crown thinning. The cankered stems may be invaded by secondary fungi or insects, further weakening them.

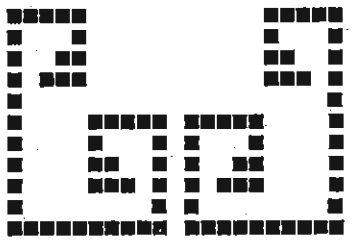
Alder bark beetles and flatheaded borers have also been observed on some of the damaged and dead red alder. Injury is caused by larval feeding galleries that girdle branches or stems or kill small patches of tissue. These damaged areas may then be invaded by secondary insects or fungi that further weaken the area leaving it prone to breakage. These insects are also opportunists, requiring a weakened tree for successful attack and breeding.

The types of damaging agents observed indicate stress of one type or another. All root disease pockets may not be suitable alder sites. Particular attention should be paid to evaluating the capability of a site to support dominant alder. Perhaps some of the early red alder stock that was planted wasn't suited to particular sites. There is little we can do about environmental conditions that stress a tree. We can,

however, reduce the stress associated with site and stock conditions by carefully evaluating sites and carefully tending and planting trees.

Not all potentially stressful site conditions are obvious. We do not yet understand why patches of planted and natural red alder mortality have shown up in a 4-year-old planting in western Washington. There do not appear to be obvious microsite differences in areas of the plantation where trees are thriving versus those patches where they are dying. The insects and fungi found in association with the damage are the same players we have already talked about-the stressors are unknown.

There is no doubt that concern about disease or insect damage to red alder will increase with increasing investment, regard, and management of the species. In fact, that concern has already surfaced. Our experiences should be similar to those we've had with managed stands of conifers. Each site visit will bring us closer to understanding the roles of the insects or fungi previously implicated as potential damaging agents, Each year of plantation development will provide us with new information on what potential economic impacts we can expect. We will probably develop a new list of agents who were never players in the natural stands of alder but will be in managed stands. We face a number of challenges associated with red alder management in the Pacific Northwest. We face even more for we are beginning to manage the other hardwood species in our forests as well. Hardwood pathology is a new emphasis area in Oregon and Washington. We have a great deal yet to learn.



DOUGLAS-FIR DWARF MISTLETOE BROOMS AND SPOTTED OWL NESTING HABITAT, EASTERN CASCADE RANGE, WASHINGTON

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Introduction

The northern spotted owl (*Strix occidentalis caurina*) is found in the Cascade mountain range from British Columbia to the Klamath Basin of northern California. In the eastern Cascade range of Washington state, northern spotted owls have been intensively surveyed for about 5 years, and research on their ecology in this bioregion is an expanding and accelerating program.

Nesting habitat is generally characterized as mature or old-growth coniferous forest, with high canopy closure, multiple layers of canopy, and large amounts of dead and down material in the forest structure (Thomas et al. 1990). Spotted owls do not construct their own nesting structures, but they have been known to use cavities in snags and in live trees, dwarf mistletoe brooms, abandoned nests of other raptors, or even a conveniently shaped large branch junction. In nesting habitat studies conducted in western Oregon and in California, however, the majority of nests were in cavities (LaHaye 1988, Forsman 1984). A survey of nests in the eastern Cascade range in Washington found 55% were in dwarf mistletoe brooms (Irwin et al. 1989).

We initiated a project to characterize spotted owl nests in dwarf mistletoe brooms; to characterize forest stands containing spotted owl nests, and to determine if there were differences in site, stand, and pest attributes between stands with dwarf mistletoe broom nests and stands with cavity nests; to determine if there were differences in site, stand, and pest attributes between stands with spotted owl nests and stands without nests; and to determine if a significant correlation occurred between the incidence of dwarf mistletoe brooms suitable as spotted owl nests, and mean stand dwarf mistletoe rating (DMR).

Methods

We selected 29 sites for this study from the pool of known spotted owl nests on the eastside of the Cascade range in Washington. We eventually included 9 cavity nests in our study, from a total of 15 known on the Wenatchee National Forest by July 1990. The forest stands in which each nest tree were delineated using aerial photogrammetry techniques, using parameters of stand structure, density and species composition. Another forest stand within 0.25 miles of each nest tree was selected at random and included in the study.

The crew collected data from nest sites and forest stands using a modified Region 6 Stand Exam. Each tree was rated using the Dwarf Mistletoe Rating method. To express the intensity of infection for each stand a dwarf mistletoe infection (DMI) rating was calculated by summing up all dwarf mistletoe ratings for each tree and dividing by the number of infected trees. Additionally, each dwarf mistletoe broom was tallied, and it's size estimated in 3 dimensions. The percent of the broom that was dead foliage was recorded. The field crew tallied and measured all snags on a transect placed between the stand exam plots. Treatment of the random paired stands was similar.

Results

Dwarf mistletoe brooms used as nests ranged in size from 60 ft^3 to 8,000 ft^3 (estimated ocularly). Size of dwarf mistletoe brooms measured on all plots in nest stands ranged from < 1 ft^3 to 23,000 ft^3, and nearly one fourth of these were relatively small (< 10 ft^3). Recognizing that some dwarf mistletoe brooms would be too small to be useful to a nesting owl, we reduced the data set by excluding brooms smaller than 60 ft^3, the minimum size of nest brooms in our sample. We categorized the brooms as small or large, using the median of the data set (284 ft^3) as the breakpoint. We compared proportions of nest brooms and all brooms in small and large categories, and found that spotted owls selected significantly more large dwarf mistletoe brooms as nests than statistically expected ($Z = 5.18$, $P < 0.001$). Significantly more nest brooms were opaque (no sunlight was observed through the broom by field observer) than statistically expected.

Site attributes were similar for both dwarf mistletoe nest stands and cavity nest stands, but distance from the Cascade crest was very different for the 2 stand types. Distance averaged 20.7 mi for dwarf mistletoe nest stands, and 11.0 miles for cavity nest stands. Average height, trees/acre, and basal area/acre were all similar between stand types. Average tree diameter was significantly larger in cavity nest stands than in dwarf mistletoe nest stands. Snag densities were higher in dwarf mistletoe nest stands, yet the snags in cavity nest stands were larger, on average ($X = 11.0$ inches in dwarf mistletoe nest stands, 12.7 inches in cavity nest stands, t test, $p = 0.005$).

Stand DMR averaged 0.53 in dwarf mistletoe nest stands, and only 0.002 in cavity nest stands. Stand DMI averaged 2.41 in dwarf mistletoe nest stands, and 0.34 in cavity nest stands. Average number of DM brooms per acre was 87.3 in dwarf mistletoe nest stands, and 0.4 in cavity nest stands. All of these differences were statistically significant.

In considering availability of cavities as potential nest sites for spotted owls, we were unable to sample the forest for cavities, per se. We reduced our tree and snag samples by eliminating those <20 inches DBH, and compared densities of these large trees and snags by stand type. While much reduced from the total number of trees/ac and snags/ac, these figures are not statistically different between stand types. Therefore, our data indicated that while spotted owls have potentially useful cavity-bearing large trees and snags in both types of nesting areas, they do not have potentially useful dwarf mistletoe brooms available in both types of nesting areas. The forest stands containing both kinds of nests in our sample were similar in many respects, but cavity nest stands had larger diametered trees, on average, and were closer to the Cascade crest than were the dwarf mistletoe nest stands.

Measuring the density of dwarf mistletoe brooms potentially available to spotted owls would be difficult and expensive. We tested the relationships between stand DMR and brooms/acre, and between stand DMI and brooms/acre. We generated a regression model with stand DMR as the independent variable, and with brooms > 60 ft^3 as the dependent variable, and found that the R^2 value was 0.70. DMR may therefore be a convenient index to availability of potential nest brooms.

This study supports the conclusion that dwarf mistletoe infection is an important component of suitable spotted owl nesting habitat in the eastern Cascades of Washington. Dwarf mistletoe infection should be carefully considered as one component of the eastside forests that could be actively managed when the goal is to maintain, or to create, spotted owl nesting habitat.

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RATING FOR ROOT DISEASE SEVERITY

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Root disease severity rating is applied to ground plots or polygons, or polygons viewed in aerial photographs. In all cases, the severity rating is applied on the basis of the amount of CHANGE FROM NORMAL in the polygon or plot that is ATTRIBUTABLE TO ROOT DISEASE EFFECTS. Familiarity with the local conditions is essential for application of these rating system. A clear distinction is drawn between the overstory trees of a non-root disease tolerant species (referred to as the susceptible species) and the understory that is a result of disease-cause openings in the canopy. Uneven aged structure resulting from other causes is considered normal (with respect to root disease), the disease severity is based only on the changes from normal caused by root disease. This, of course, will include a considerable amount of bark beetle activity in as much as the beetles have the habit of co-habitating with root disease.

They are subjective rating systems; a communication tool inspired by the movie "10" in which women's appearance is being rated on a numerical scale. Some basic appreciation for the beauty of root disease may be required to use this system effectively. The scale is intended to reflect relative impacts useful for management decisions. The lack of clear distinction between adjacent classes reflects the fact that disease severity does not, in reality, jump from class to class. Two users need not be concerned if they rate the polygon or plot differently by a class. A difference of more than one class indicates that the two users need to compare thoughts on the rating.

Cutting history, age, species composition, and physical features of the site must be taken into account when applying these rating systems. I recommend that a user ***visualize both ends of the scale, no root disease versus no surviving overstory, for each polygon or plot, and then "find" the position of the polygon or plot between the extremes***. Where, for example, thin or dry soils limit stocking density, the "no root disease" end of the scale will have considerably less canopy than sites with higher site potential.

GROUND PLOT RATING SYSTEM

Some prefer to visualize canopy reduction while others are more comfortable with estimating ground area of the plot impacted. The ground area impacted is especially applicable to young stands such as sapling size where canopy closure would not have occurred even in the absence of root disease and in partially harvested plots where it can be difficult to visualize the difference between the canopy-opening effects of the harvest and the effects of root disease. The ground are impacted is estimated by projecting the drip line of overstory crowns onto the ground and estimating the percentage of the area occupied by clearly symptomatic or dead trees. For those of us who have spent more time looking down than up, a more direct method is to visualize the root system of infected trees. Using this method, class 2 would be up to 20 percent of the root area affected, 3 would be 30 percent and so on. This seems to be most comparable to the canopy reduction classes as described in Table 1. Again, if the user tries to make this too precise, the advantages of this as a rapid assessment technique are lost. The point is attach a relative value to the disease severity without trying to parametize the value excessively.

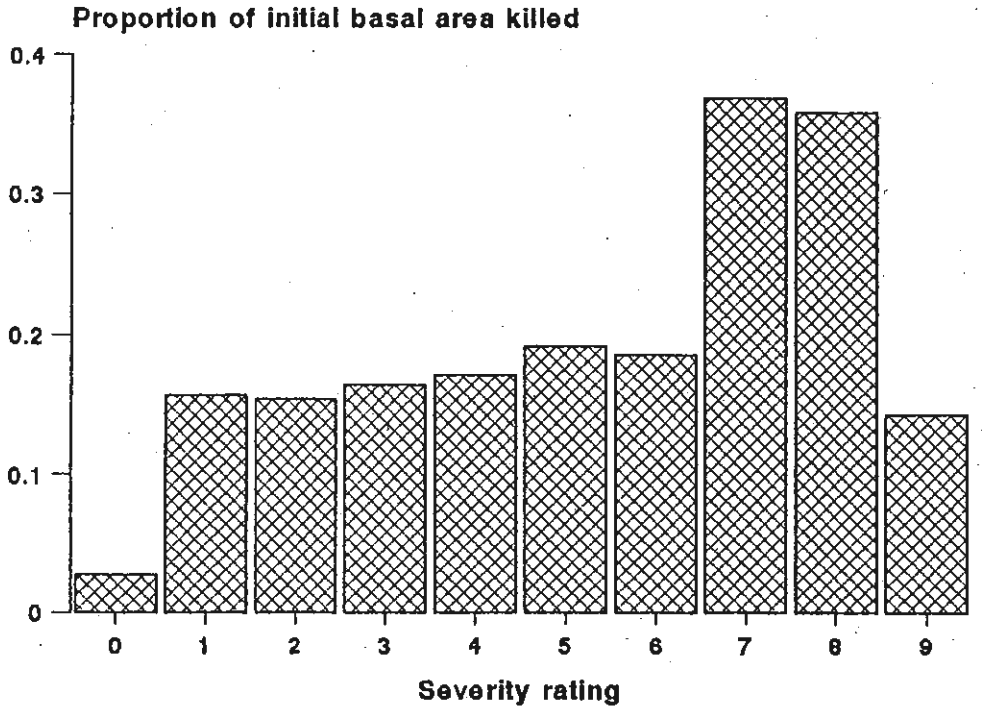
TABLE 1: ROOT DISEASE SEVERITY RATING FOR GROUND PLOTS

CODE	CRITERIA
0	No evidence of root disease visible within 50 feet of plot.
1	Root disease present within 50 feet of plot but no evidence of disease on plot.
2	Minor evidence of root disease on plot, such as a suppressed tree killed by root disease, or minor part of overstory showing symptoms of infection. Little or no detectable reduction in canopy closure or volume.
3	Canopy reduction evident, up to 20 percent. Usually as result of death of one codominant tree on otherwise fully stocked site. In absence of mortality, numerous trees showing symptoms of root disease infection.
4	Canopy reduction at least 20 percent; up to 30 percent as result of root disease-caused mortality. Snags, and downed trees removed from canopy by disease as well as live tree with advance symptoms of disease contribute to impact.
5	Canopy reduction 30-50 percent as result of root disease. At least half of ground area of plot considered infested with evidence of root disease-killed trees. Plots representing mature stands with half of their volume in root disease-tolerant species usually don't go much above severity 5 because of the ameliorating effect of the disease tolerant trees.
6	50-75 percent reduction in canopy with most of ground area considered infested as evidenced by symptomatic trees. Much of the canopy variation in this category is generally a result of disease-tolerant species occupying infested ground.
7	At least 75 percent canopy reduction. Plots which reach this severity level usually were occupied by only the most susceptible species. There are very few of the original overstory trees remaining although the infested ground area is often densely stocked with regeneration of the susceptible species.
8	The entire plot falls within a definite root disease patch with only one or very few susceptible overstory trees present.
9	The entire plot falls within a definite root disease patch with no overstory trees of the susceptible species present.

A field test of the ground plot rating system, done in 1984 and repeated 1987, demonstrated a low variance in rating after 4 hours of field training with stand examination crews with various levels of experience. In only 10 percent and 8 percent of the cases, ratings among 6 and 4 crew people, respectively were 2 or more classes apart. However, in 63 and 57 percent of the cases, at least one crew person rated the same plot differently by one class.

The average annual mortality rates over 5 years, measured on 216 permanent plots on Fernan Ranger District provide a reasonable correlation with root disease severity classes assigned to the plots at the time of establishment (Hagle 1985) (Figure 1).

Figure 1: 5-year reduction in Douglas-fir and grand fir.
Average for three habitat type groups



SEVERITY RATING ON AERIAL PHOTOGRAPHS

Whether the polygons are stands or root disease severity classes, this is surely among the most rapid techniques for assessing current levels of root disease activity on sites. I have single-handedly delineated and severity rated polygons for 25,000 acres using 1:12,000 true color photography and a contour map, with minimum polygon size of approximately 20 acres, in less than 2 days. The scale of delineation (minimum polygon size) should correspond to the scale of analysis needed. This, in turn, will dictate the scale needed in the photography. Williams (1973) used 1:4000 color infrared aerial photography to identify individual root disease patches.

Stereo pairs of vertical true color or color infrared aerial photographs of 1:15,840 or larger scale are recommended. Magnification using a 10X lens mounted on the stereoscope was useful for careful examination of some trees and suspected downfall. When using 1:15,840 or similar scale, some stand

data is useful to be sure that species identifications during photo interpretation are generally correct. Croft and others (1982) have provided some nice guidance on identifying species.

Familiarity with the general conditions in the area is essential for good interpretation of the symptoms seen in the photography. I use stand examination information for at least a sample of stands in each area interpreted. These data provided not only a general sense of species composition and structure but some idea of the types of insect and pathogen activity found in the area. There is no replacement for ground truth in a sample of the interpreted polygons. Conversely, the photography often provides a very useful perspective which is not easily obtained by walking through a stand on the ground.

Comparison of ground severity ratings assigned to 216 permanent plots to photo ratings assigned from 1:12,000 photography of the plots (pin-pricked on the photos) (Hagle 1985), revealed a standard deviation of 0.94 using a 10-point scale, or 9.4 percent. The ground plots were rated by district crews and aerial photography was rated by an FPM technician (Cathy Stewart) without prior knowledge of the ground rating assigned.

Like the ground plots, canopy closure or area occupied by root disease patches are the basic characteristics used to assign severity in photo rating polygons (Table 2).

Table 2: RATING FOR ROOT DISEASE SEVERITY FROM AERIAL PHOTOGRAPHY

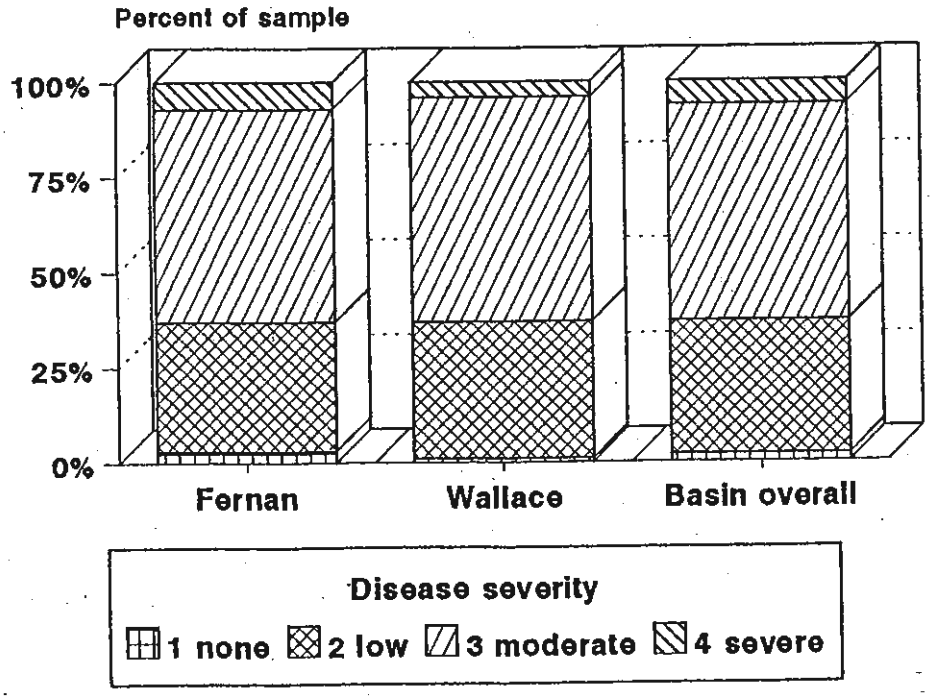
CODE	CRITERIA
0	No evidence of root disease visible in the photo.
1	Root disease present in small, scattered patches of mortality or few, scattered dead trees. Barely distinguishable in the photo.
2	Root disease present in small, scattered patches, infrequent individual dead trees or few larger patches constituting less that 10 percent of stand area.
3	Root disease patches sufficient to serve as distinguishing characteristic for stand delineation or 10-20 percent canopy reduction by scattered mortality.
4	Small and/or large root disease patches obvious, resulting in 20-30 percent overall canopy reduction or 20-30 percent of stand area in non-stocked patches.
5	Small and/or large root disease patches obvious, resulting in 30-50 percent overall canopy reduction or 30-50 percent of stand area in non-stocked patches.
6	Small and/or large root disease patches resulting in 50-75 percent overall canopy reduction or 50-75 percent of stand area in patches which have few remaining overstory trees, of an non-root disease tolerant species, consistent in age with the non-root disease stand origin
7	At least 75 percent of the stand area in root disease patches which have few remaining overstory trees, of a non-root disease tolerant species, consistent in age with the non-root disease stand origin. Or scattered mortality which has resulted in at least 75 percent reduction in canopy.
8	All of the stand area occupied by root disease patches with a few remaining overstory trees, of a non-root disease tolerant species, left which are consistent in age with a non-root disease stand origin.
9	All of the stand area occupied by root disease patches with no remaining overstory trees, of a non-root disease tolerant species left, which are consistent in age with a non-root disease stand origin.

The first major application of the photo rating method was complete coverage of the Horizon Resource Area on Fernan Ranger District of the Panhandle National Forests in Idaho (Horizon EIS). This provided a link between the current root disease conditions and stand exam data used to run the Stand Prognosis model with the Western Root Disease Model to project not only managed stands but the "no action" alternative for the 90 percent of the area not considered for management activity within the 10-year planning period.

This was followed by a two-District (Fernan and adjacent Wallace Ranger District) assessment of root disease using a 20-25 percent sample of the Douglas-fir and true fir cover types (most root disease-prone species). In general, a cover type is identified as the species comprising a plurality of the trees on the site. The aerial photography was severity rated by personnel on each of the two Districts and a joint report of findings was prepared for the major watershed with constitutes the land base of the two Districts (Hagle and others 1992). This report is the basis for further analysis of management needs in the Coeur d'Alene basin to address increasingly acute watershed problems caused, in part, by the loss of canopy cover due to root disease effects.

Figure 2: Coeur d'Alene Basin

Percent of acres by severity class



Current application of the photo and ground severity rating methods also include providing information for Forest Plan revisions and broadscale analysis of forest health for Ecosystem Management applications.

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PANEL: INCORPORATING INSECT AND DISEASE INFORMATION INTO FOREST PLANNING

Moderator: Jane E. Taylor

Participants: Joyce E. Thompson, Ellen M. Goheen, Susan K. Hagle, Judith E. Pasek and John V. Arena

INCORPORATING INSECT AND DISEASE EFFECTS INTO FOREST PLANNING

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Introduction

The demand for the resources of the National Forests is ever increasing. As the American population grows, there is more demand for the timber products, recreation opportunities, clean water and air, wildlife and other resources of the forests. Any factor which reduces the availability and quality of these resources exacerbates the problem. Forest insects and disease are factors which compound conflicts of resource use by reducing the growth of forests and, in some circumstances, causing tree mortality. Accounting for insects and disease effects in strategic planning is essential for forest managers to understand the availability of resources and how they can manage the forest in a healthy, sustainable condition.

The National Forest Management Act (NFMA) of 1976 required National Forests to develop strategic, interdisciplinary, multiple-use Land and Resource Management Plans (Forest Plans). Most National Forests have completed these Plans. Forest Plans are an opportunity to guide managers on which silvicultural and management practices to apply in order to keep the forest in a healthy condition and prevent adverse effects from insects and disease. For some pests, such as root disease, preventative management is the only feasible tool available to managers today.

When proactive management fails and timber salvage or pest suppression is necessary, managers will have a better understanding of tradeoffs involved if they are analyzed in Forest Plans. Additionally, the programmatic nature of the plans will allow managers to take more timely intervention against pest outbreaks because much of the environmental analysis for timber salvage or pest suppression would already be conducted and documented.

This paper will describe opportunities for incorporating insect and disease information into the analysis of forest management tradeoffs. First, the stage will be set by providing background on National Forest planning in the United States and describing how insects and disease were addressed in the development of forest plans. Next, a description of the forest planning process will be presented, highlighting areas where it is appropriate for incorporating insect and disease.

Background on Forest Planning

National Forests in the United States are managed under the Multiple-Use Sustained Yield Act of 1960 and the National Forest Management Act of 1976 for the various multiple-uses of the forests, such as water, timber, forage, wildlife, fish and wilderness. The Acts further require that the resources of the National Forests be managed for sustained yield to ensure a continued supply of goods and service to the American people. Development of interdisciplinary, multiple-use Forest Plans is required under the Forest and Rangeland Renewable Resources Planning Act of 1974 and the National Forest Management Act of 1976.

Forest Plans, in conjunction with their accompanying Environmental Impact Statements, examine the trade-offs of allocating the limited supply of land and resources among the various demands of forest user groups. Generally, Forest Plans determine:

- forest-wide multiple-use goals and objectives,
- forest-wide standards and guidelines,
- management area direction,
- lands suitable for timber production, and
- monitoring and evaluation requirements.

Plans are required to be revised about every 10 years or when conditions have significantly changed to the extent that the plan is not longer valid. The majority of National Forests have completed their plans and some are beginning revision. Several plan revisions have been precipitated by insect and disease impacts on the forest that were unanticipated and/or unaccounted for in the development of the forest plan.

The Situation

In *Forest Health Through Silviculture and Integrated Pest Management - A Strategic Plan* (USDA Forest Service 1988), a problem was identified that "(i)ntegrated forest pest management considerations area not adequately incorporated in forest resource management planning processes." The specific rationale was:

- Plans mention but do not provide for practicing integrated pest management.
- Plan analyses projecting productivity rarely make necessary adjustments for potential losses to forest pests.
- Means for predicting some forest pest-caused impacts were not available for the current planning cycle.
- Failure to address forest pest impacts in the plans and stand management prescription could exacerbate existing and potential pest problems.
- Priorities for forest management activities rarely consider management of forest pests.
- Economic or biological thresholds triggering pest prevention or suppression activities have not been extensively defined or included in forest plans.

Several workshops and task forces have echoed these concerns. Documents which provide additional insight into the challenges of incorporating insect and disease into forest planning, along with offering solutions, include; *Forest Health Strategic Plan for the Northern Region* (USDA Forest Service, 1992), *Integrating Pest Impact Information in the Next Planning Cycle* (Eav, et al. 1989) and *Integrating Forest Health with Forest Plan Implementation, Monitoring and Revision* (USDA Forest Service 1992).

To illustrate the intensity of the problem, following is an example of how insects and disease was incorporated in the Huron-Mantisee National Forest Plan (USDA Forest Service 1983).

> "Use integrated pest management methods to minimize or prevent the development of pest problems and silvicultural prescription development following an appropriately documented environmental analysis. Where pest problems are unavoidable, select the solution which provides the most beneficial

method based on objectiveness, effectiveness, safety, environmental protection, and cost. Federal Insecticide, Fungicide, and Rodenticide Act ... will be followed."

There was no elaboration of what constituted integrated pest management methods, what was an acceptable solution, or the tradeoffs involved among alternative methods. This is typical of how insects and disease were addressed in the development of the plans. Of course, there are exceptions where forests actively incorporated insects and disease into their planning process. Generally, these were forests that had insects and disease outbreaks during the period when their plan was being developed. The Deschutes National Forest is an example of a forest that actively incorporated insect and disease into their plan and planning analysis (USDA Forest Service 1990).

The Forest Planning Process

An understanding of the forest planning process is necessary in order for forest pest managers to interact effectively with forest planners and interdisciplinary planning teams. First, I will present an overview of the process. Then, I will address specific steps in the process for incorporating insect and disease effects. (For more insight into the forest planning process consult *Principles of Land and Resource Management Planning* (Jameson, et al. 1982).

Overview of Forest Planning

Federal Regulations that govern the forest planning process are currently being revised. Since these regulations are not final, the process which I will refer to is the one used for development of plans. One of the primary difference between the regulations that guided forest plan development and the proposed revised regulations is the perspective of when the process begins. The proposed regulations recognize Forest Plans as completed and will guide revision of the plans. With the proposed regulations, the process will be similar to that used to develop plans but emphasis will be placed on monitoring and evaluation to identify the "need for change" that would instigate revision.

Following is the 10-step planning process that guided the development of plans. While the planning process appears to consist of a logical progression of steps, the actual process is an iterative process where findings at one step result in returning to previous steps to make adjustments.

1) Identification of Issues
2) Development of Planning Criteria
3) Inventory Data and Information Collection
4) Analysis of the Management Situation
5) Formulation of Alternatives
6) Estimate Effects of Alternatives
7) Evaluation of Alternatives
8) Selection of Alternative
9) Plan Implementation
10) Monitoring and Evaluation

Forest planning is accomplished by an interdisciplinary team representing the variety of resource disciplines within National Forests. Interdisciplinary team member selection frequently reflects the planning issues. Whether or not forest pest managers are on the team depends upon their availability and if insects and disease are viewed as a crucial issue. If forest pest managers are not on the team, they could provide data, information and analysis results to an individual on the interdisciplinary team, probably a forester or ecologist. To improve the transfer of knowledge, forest pest managers need a better understanding of the data and information that are appropriate for strategic planning by working with the interdisciplinary team.

Each planning situation is unique; there is no single solution to the challenge of incorporating insects and disease into forest planning. While I can't offer solutions, what I can offer are suggestions and examples to help forest pest managers and planners understand where they can work together. The remainder of this paper will elaborate on how forest insects and disease effects can be applied in each step of the planning process.

(1) Identification of Issues

Forest planning revolves around issues on how to manage the forest. Issues are identified by the public, other agencies and other Forest Service personnel. The health of the forest should be an issue on every National Forest. Identifying forest health as an issue is crucial in order for insects and disease being actively incorporated into the planning process. Potential forest health issues are reflected in the rationale for incorporating pest management into forest plans listed in the forest health strategic plan (USDA Forest Service, 1988). These include:

> What are the effects of insects and disease on the productivity of the forest; e.g., timber allowable-sale-quantity (ASQ) and long-term sustained yield capacity (LTSYC)?
>
> What management prescriptions could reduce existing and potential pest problems?
>
> What stands are at risk and what are the priority areas for management activities to reduce pest problems?
>
> When do insects and disease become pests, i.e. when does damage become ecologically and/or economically unacceptable?
>
> What are the tradeoffs of different pest management scenarios in regards to other resources, for example, water quality, wildlife habitat, or visuals?

(2) Development of Planning Criteria

Development of planning criteria identifies public policy, process and decision-making criteria that will guide the planning process. Public policy criteria identifies requirements of laws, regulations and directives that are central to the planning process. Process criteria guides data gathering, analysis and formulation of alternatives. This includes identifying the quality, accuracy and reliability of data that will be used in planning. It also includes validating the analytical methods that will be used. Decision criteria provide guidance to the interdisciplinary team on how to select the proposed alternative.

(3) Inventory Data and Information Collection

Data for forest planning come from a variety of sources including monitoring, surveys and inventories. Other information that is needed includes knowledge of the interactions between resources and ecological conditions, and information on management costs. Some of the information used in forest planning may be qualitative and based on professional judgement. The data and information needed for forest planning depend upon the issues to be addressed.

Eav et al. (1989) recommended information needed for planning to include major pests, geographic areas of impact by major pests, resources affected by the pest, and the range of treatment options available. To address the issue of the effects of insects and disease on the long-term productivity of the forest, Reed and Errico (1987) elaborated on information needed which includes continuity of infestations of insects and disease (e.g., intervals or continuous), rate of damage (e.g., proportion of an area affected during an infestation) and the recoverability of the infested timber.

(4) Analysis of the Management Situation

The Analysis of the Management Situation (AMS) describes the current situation on the forest and implications of continuing current management practices into the future. The supply and demand of the forest resources, suitability of lands for resource production, and potential management prescriptions are examined. Since forest insects and disease affect the supply of the forest resources and management practices affect the occurrence of insects and disease, it is appropriate for forest pest managers to be involved in describing the current situation.

During the AMS stage, analysis of the forest resources begins. Analysis is not restricted to the AMS but is essential in other stages of the planning process as well. However, I will introduce planning analysis techniques here and discuss other applications as they relate to insect and diseases later.

The primary analysis tool for forest planning is FORPLAN, a linear programming model used to analyze land allocation, resource, and economic tradeoffs of alternative multiple-use management scenarios. The basic land unit used in FORPLAN is the analysis area. Analysis areas are a combination of up to six layers of land information that respond similarly to management. Forest pest managers need to work with planners to assure that the timber age class and structure classification is appropriate for reflecting the effects of insects and disease and management prescriptions to prevent or reduce adverse effects.

Timber yield estimates used in FORPLAN are derived from growth and yield models such as Prognosis. Pest extensions to the growth and yield models can provide estimates of the reduction in timber yields from insects and disease. If pest models are not available, estimates of timber volume reduction from inventories and professional judgement are better than no information.

(5) Formulation of Alternatives

Alternative forest management scenarios are developed to address issues. Alternative scenarios will be used to examine the tradeoffs in Step 7 - Evaluation of Alternatives. In the development of alternatives, the desired future condition of the land and resources is defined and management standards and guidelines for achieving the desired future condition are developed. Standards and guidelines assist managers into identifying management prescriptions for site-specific projects in order to meet long-term goals and objectives.

Alternatives need to include alternate strategies for long-term prevention of pests and possible pest suppression activities that may occur if necessary (Stark 1984). Hazard rating models are tools which can assist in determining which stands should become priority for management activities and which silvicultural prescriptions will create healthy stand conditions (Stoszek and Mika 1984).

(6) Estimate Effects of Alternatives

Biological, social and economic effects of each alternative are estimated. Estimating effects frequently centers on issues and includes beneficial and detrimental effects. Estimating the effects of the alternatives frequently results in developing new alternatives because issues were not fully addressed with the previous range of alternatives.

Alternatives reflect changes in management practices from the current situation. Forest pest managers need to examine the implications of changed practices on insect and disease populations and effects on resources. The effects of insects and disease on the long-term productivity management practices of the forest in each alternative can be analyzed with FORPLAN. The model can be used to estimate reductions in the timber allowable-sale-quantity and long-term sustained yield. Insects and disease do not necessarily result in reduced timber yield from the forest. Johnson (1984) found that incorporating insect and disease into the FORPLAN model on the Clearwater National Forest did not affect the amount and timing of timber

harvest forestwide; however, there was a shift in silvicultural prescriptions and the location and timing of harvest within the forest.

(7) Evaluation of Alternatives

After the effects of each alternative are estimated, alternatives are compared and evaluated on how well they address the issues. Comparison of alternatives assists in identifying the tradeoffs among resources, land allocations, and management prescriptions associated with the different alternatives. For instance, an alternative with no pest suppression could be compared to an alternative with maximum pest suppression to determine the benefits and costs of protection.

Following evaluation, the interdisciplinary team recommends a preferred alternative based upon the decision criteria and a draft Forest Plan and environmental impact statement are issued.

(8) Selection of Alternatives

After the draft Forest Plan is issued, there is a period of public comment. Any new substantative issues identified by the public or others need to be addressed. Frequently, this results in more information collected, new alternatives formulated, effects of the alternatives estimated and alternatives evaluated. Forest pest managers involvement with each of these steps would be similar to that mentioned above.

When the analysis is complete, the Regional Forester selects the preferred alternative and the final forest plan and accompanying environmental impact statement are issued.

(9) Plan Implementation

Forest planning does not end after the Forest Plan is final. Management direction from the plan needs to be applied on projects. Forest Plans provide guidance on how to manage the forest. While a plan includes recommendations of management prescriptions for projects, it does not dictate what will occur on a site-specific project. Decisions on projects require a site-specific analysis of environmental conditions and tradeoffs.

Forest pest managers have traditionally been involved with site-specific projects in which insects and disease are problems. This involvement needs to continue. However, there needs to be greater emphasis on preventative management to keep forests healthy. Forest Plan standards and guidelines provide the best opportunity for wide-spread application of preventative measures. There needs to be involvement of forest pest managers on select projects without immediate insect and disease problems in order for them to understand how site-specific decisions are made and how they can more effectively provide guidance in Forest Plans.

(10) Monitoring and Evaluation

Monitoring and evaluation is the key to revising Forest Plans. Revisions will be instigated by a "need for change" identified from monitoring and evaluation of management practices, environmental effects and public perceptions. The "need for change" will be used to determine what are issues to analyze in the forest plan revisions.

Forest pest managers need to be actively involved with monitoring and evaluation of forest plans in order to assure that silvicultural practices are maintaining healthy forests and that the predicted effects used in the planning process are accurate. The degree of unaccounted or unanticipated effects of insects and disease on long-term timber yields can be evaluated with sensitivity analysis by changing yields in FORPLAN. Monitoring and evaluation will also determine when timber salvage and/or pest suppression is necessary.

Conclusion

A recurring theme has been the importance of issues in the forest planning process. Since most National Forests have completed their Plans, issues will be identified through monitoring and evaluation.

In order for insects and disease to be addressed at the strategic level of planning, involvement of forest pest managers will have to be at almost every step in the process. Forest health and the relationship to insects and disease should be addressed in every Forest Plan, regardless of whether or not the forest currently has insect and disease problems. Given the limited resources of Forest Pest Management, direct involvement may be unrealistic. Techniques and procedures need to be developed to facilitate sharing information regarding insects and disease with the Forest Plan interdisciplinary team.

By taking a proactive approach of planning for insect and disease effects, we can help to assure a healthy forest that can produce sustainable forest products.

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IMPROVING FOREST RESOURCE INVENTORIES: APPROACHES FOR OBTAINING DISEASE AND INSECT INFORMATION FOR FOREST PLANNING IN THE PACIFIC NORTHWEST

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Integrated forest pest management considerations are not adequately incorporated in forest resource management planning processes. In order to evaluate current conditions and future impacts to resources, major pests must be identified, their damage quantified, the major geographic areas of impact by pests identified, and the data assembled and analyzed. One way of addressing this issue is to develop procedures for including pest impact information in the next planning cycle.

In the Pacific Northwest, vegetation inventories, with emphasis on timber data, provided the forest planning numbers. Recently those numbers have been questioned because of apparent discrepancies between the outputs generated by the growth and yield models using the inventory data and the reality of available resources on the ground. Allowable Sale Quantities were not being met. When a group of forest planners met at a FORPLAN model workshop in 1991, they were asked to resolve the question "Where has all the volume gone?" Several answers were proposed. They included: 1) Losses by diseases and insects not being adequately accounted for and 2) Forest Inventories not being reliable or relevant to the resource questions being asked. From the standpoint of addressing pest management concerns, these two answers are inextricably tied. Forest inventories have not been able to provide reliable information on the incidence, damage, and severity caused by even the most obvious of diseases and insects.

Brief History of Inventory Procedures in the Pacific Northwest

Prior to 1979, PNW Regional inventory used a 1.7 mile systematic grid of 3- or 10-point clusters to sample timber volume, growth, and mortality. All forest conditions were not sampled and the sampled conditions had very little planning integration with other resources. Plot procedures were also somewhat inconsistent.

From 1979 - 1982 the inventory schedule was accelerated to meet forest planning objectives. Forests were typed from aerial photography and delineated into stands of homogeneous conditions. Mapping conditions were defined to represent silvicultural treatment opportunity as interpreted by the mappers. The inventory objective was timber, for the timber portion of the forest plan. The systematic grid design was replaced by a pre-stratified design optimizing volume at the stratum level. Point or plot clusters were used. Attempts were made to build consistency of design, techniques, procedures and variables into the system. During this period the first contracted inventories were completed.

Inventory objectives were reevaluated in 1983 - 1984. Resources other than timber needed to be considered if the inventory process was going to be useful to forest planning. Wildlife, ecology, planning, forest pest management, geometronics, and management systems were brought together with timber to develop a new approach to inventory. Vegetation was emphasized as the common link among all the resources; all resources are either influenced by or influence vegetation. Species other than classic timber trees and conditions other than merchantable standing trees were included in some cases and land was classified according to physical attributes not according to resource definitions.

The first attempts at the plan-driven vegetation inventories began in 1985. A pre-stratified sample design defined by planning was used while sample intensity was defined by timber. The ten-point cluster plot design was maintained. Timber measurements were reduced by approximately 60% to free resources needed to collect information on standing dead trees, down trees, crown attributes, indicator vegetation, physiographic and site information.

New types of surveys were begun at the Regional level in 1987. The Managed Stand Survey was established to provide a long term growth and yield database for the development and calibration of growth and yield models as well as provide monitoring capabilities for stand development. Managed stands are considered to be those which have been planted or established through natural regeneration methods and are receiving some type of stocking level control. These plots are currently on a 5-year remeasurement schedule. The Mature-Over Mature Survey was a first attempt at mapping and inventorying old growth. This survey highlighted the problems associated with the concepts and definitions of old growth that were in use at the time and led to defining the elements that make up old growth vegetation so that old growth could be mapped.

Obtaining Disease and Insect Information from Regional Inventories

Using inventory data to obtain adequate disease and insect information necessary for forest planning was not possible in the last round of planning. Those Forests relying on older timber inventories often did not have adequate information on mortality because dead trees were ignored. As such, it was impossible to ascertain the level at which diseases and insects were effecting tree growth and survival in those stand types. Where Forests were able to use more comprehensive vegetation inventories, quality of disease and insect information was inconsistent from Forest to Forest and from field crew to field crew. The inconsistencies appear regardless of whether inventories were contracted or completed in house. Rarely do root disease-affected trees appear in plot data. Subsequent visits to plots by pathologists suggest that even ratings for dwarf mistletoe-affected trees could not be relied on. Use of a plot cluster design to obtain information on unevenly distributed single or groups of dead trees was also questioned. As inventory designs changed to sample vegetation types, it was assumed that delineated stands would consist of homogeneous vegetation. Patchy distributions of disease and insect-affected trees within homogeneous vegetation were not considered.

Data Needs for Resources other than Timber

Inventory-generated data pertinent to describing resources other than timber were also lacking during the last round of planning. Wildlife habitat classification, particularly regarding cavity-nesting birds, was not addressed adequately in large scale inventories. As with disease and insect damage, standing dead trees tend to be patchily distributed and sampling procedures were not designed for that type of distribution. Condition and use codes had not been developed. These considerations were built into more recent inventory procedures such as the Pacific Yew and old-growth inventories, however questions remained regarding sampling design and intensity. Fuel inventories and ecological descriptions of inventoried sites were also inconsistent.

Forest Pest Management's Strategy for Improving Inventory Procedures

In the past, Forest Pest Management (FPM) has provided input into developing inventory procedures predominantly by supplying damage and severity codes used by field crews. Training the crews in identification of major diseases and insects was sporadic and became more difficult as inventories were contracted. The need for insect and disease information is crucial and recently the Pacific Northwest Region developed a strategy for improving the quality of disease and insect data collected during any inventory procedure. This approach has been accepted by the Inventory group in Timber management in the Region and includes:

* Active participation with Timber Management in the design and testing of new inventory procedures to meet insect and disease information needs for forest planning.

* Developing a certification procedure for inventory contractors so that disease and insect identification skills can be demonstrated. This includes the production of appropriate field guides and demonstration test plots.

* Requiring intensive training in disease and insect identification for inventory contract inspectors.

* Increase in contract penalties for missing or erroneous information on the major pest groups or severe damage in any damage category.

* Discussion and restructuring of priorities for types and detail of disease and insect data collected.

* Demonstrating analysis procedures for inventory data, the pest models, and the consequences of not considering disease and insect impacts to resources over the planning horizon.

We can expect quality disease and insect data from inventories if the importance of the information is understood by those who design the sampling, gather the data in the field, inspect the work of those who collect those data, and use the data in analysis and planning.

Prototyping the Vegetative Resource Exam

The Region's inventory emphasis has evolved to its current focus on characterizing vegetation, particularly those elements that adequately describe structure and composition, rather than supplying information on the timber resource alone. Over the next few years, vegetation databases for each Forest will be created by classifying recent LANDSAT imagery, developing inventory strata from that classification, and sampling those strata in the field in a systematic fashion. An attempt will be made to design an inventory that can be used to describe the current vegetative conditions, so that forest planning needs are met, as well as providing information for trend analysis. The sample design has not yet been selected. Designs under consideration include a stand or vegetation polygon-based grid of points, somewhat akin to what we know as a stand exam. The inventory will be contracted, with the likelihood of a 20% inspection rate.

Because of FPM's concerns regarding the collection of quality insect and disease information useful to the forest planning process, the Regional inventory program provided FPM with the opportunity to field test the suggested inventory procedures and report on their adequacy. A partnership of wildlife biology, ecology, fuels management, inventory, and FPM at the Regional and Forest levels was formed to develop a strategy for testing these procedures and to evaluate the results throughout the field season. FPM welcomed this chance to demonstrate the importance of gathering accurate disease and insect data, to use the pest model extensions to PROGNOSIS to demonstrate impacts to vegetation over time, to alter our own descriptions and codes so that they better described impacts to resources other than timber and to test our own ideas about how disease and insect information could be collected efficiently and effectively.

The objectives of the project were: 1) to test and refine the field procedures of the Vegetative Resource Exam (VRE)- the 1991/92 version of inventory procedures which will be used on National Forest lands beginning 1993, 2) to develop and demonstrate methods of gathering information to assess current and future disease and insect damage within the VRE process, 3) to develop and demonstrate methods of gathering information to assess current and future wildlife habitat considerations within the VRE process, and 4) to test the usefulness of VRE procedures as Stand Examinations.

The Okanogan National Forest was chosen to test VRE procedures. The Okanogan NF will be one of the first Forests in the Region to receive the new VRE. They have been active participants in discussions and field testing of new vegetation databases. The range of vegetation conditions represented on the Forest is wide, providing an opportunity to test procedures in several vegetation types. Forest health and wildlife habitat concerns are important issues on this Forest as well as most other Forests in the Region. Root diseases, stem decays, dwarf mistletoes, bark beetles and defoliating insects are widespread over the various vegetation types on the Forest and cause severe damage in some locations.

Selecting Polygons: Vegetative Units (=Polygons) were selected to represent different conditions on the Okanogan National Forest. Forty polygons were sampled. The polygons were chosen from 6 quad maps representing all 3 Ranger Districts on the Forest and were based on Pacific Meridian Resource maps generated from 1987 LANDSAT scenes. Polygons were generated using a forest-built algorithm that would best combine database files for major tree species, stand structure, size class categories, and percent crown closure. Minimum polygon size was 5 acres. Access to polygons was a concern, particularly during the early stages of the project. Prior knowledge of disease and insect conditions was available for only 2 of the sampled polygons.

Inventory Procedures: To insure polygon-level coverage, a systematic grid of plots covering the entire polygon was used. The basic sampling intensity was determined before going to the field; a minimum of 3 and maximum of 10 Measure Plots per polygon were sampled by changing the grid size.

FPM objectives for data collection centered on obtaining information on the major disease and insect problems of the Pacific Northwest- root diseases, bark beetles, dwarf mistletoes, and defoliators, in such a fashion that those data were direct inputs into the appropriate pest model extensions of PROGNOSIS. This necessitated including new severity codes into the existing stand exam/inventory codes and also adding estimates of disease impact at the polygon level. For example, root disease impact estimates for a polygon included the size and distribution of centers, both important inputs to the Western Root Disease Model, which were obtained from plot examination and mapping as the field crews travelled from plot to plot.

During Phase I of the project the plot design for each polygon consisted of the following: **Measure Plots** (a detailed inventory plot comprised of a 1/100th acre plot for trees < 5" dbh, a 1/20th acre plot for trees between 5" and 13" dbh, and a variable-radius 20 BAF plot for trees > 13" dbh), **Supplemental Plots** (following the same design as Measure Plots and established at designated intervals between Measure Plots (ratio of 4 Supplemental Plots: 1 Measure Plot) when the following conditions are encountered: root diseases, bark beetles, dwarf mistletoes, and standing dead trees > 5" dbh), **Snag Plots** (fixed- area plots 264'X 66' to collect information on standing dead trees greater than or equal to 10" dbh and 10' ht. at sampling intensity of approximately .8 acres per 5 acre polygon) and **Down Woody Transects** (264' long transects for gathering information on down material at approximately 1056' per 5 acre polygon).

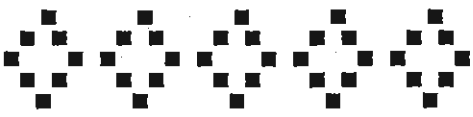
During Phase II of the project, plot designs as described above were maintained however the parameters for collecting information on standing dead trees in Snag Plots changed from 10" dbh and 10' tall to 5" dbh and 5' tall. Information on trees in Supplemental Plots was collected ONLY on those pest affected or standing dead trees, rather than all trees, with the exception of root disease affected plots.

During the final phase of the project, the ratio of Supplemental Plots to Measure Plots was reduced from 4:1 to 2:1. Down woody transect lengths were reduced to 150'. Snag Plots were dropped. A basal area tally for every plot (Measure and Supplemental) was added so that the supplemental plot information could be used to adjust the stand tables previously derived from Measure Plots only.

Results of the polygon inventories are currently being analyzed with emphasis on how effectively complete or partial data can be used in conjunction with the pest models at forest planning scales. A final sampling design for the new inventories has not been agreed upon as yet, however the efforts to prototype the 91/92 design will result in recommending the data elements that must be included in the vegetation inventory. This applies to disease and insect considerations as well as vegetation structure and composition, habitat, and fuels management needs.

Other aspects of FPM's inventory strategy are underway. A contractor certification procedure for pest identification will be in place during the late spring of 1993. Once updated identification is available, contract penalties will be adjusted. Training for contract inspectors will become operating procedure.

Even more valuable is the dialogue that has been stimulated as FPM joined with ecology, silviculture, wildlife, fuels, and inventory to discuss important data elements and sampling concerns. Duplication of inventory effort, either in description or measurement, will be greatly reduced in the Pacific Northwest in the years to come.



INCORPORATING PEST INFORMATION INTO FOREST PLANNING: PERSONAL EXPERIENCE FROM THE BLACK HILLS

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Forest Health Management, Rapid City Service Center Staff, has been working with the Black Hills National Forest for the past two years on their forest plan revision. The Black Hills is the first National Forest to begin planning for the second 10-year period as required by the National Forest Management Act. This paper is intended to share some of the things that have been learned about forest planning and what obstacles have been observed to incorporating pest concerns and information into the process.

It needs to be emphasized that forest planning is a very complex process and involves balancing a lot of different issues and concerns pertaining to forest management. Because the process involves compromise, any chosen alternative will leave some disappointments and not meet some people's expectations. The more familiar individuals are with the process, the more likely they are to provide appropriate input and be heard. It takes about 6 months of attending planning meetings two days a month before one is likely to begin to get a good feel for the process. That puts a pest management specialist who is new to the process at a little bit of a disadvantage in terms of being able to provide good pest management input from the start of the process. Being involved in the process is the best way to learn about it, but it is also very time-consuming. Another way to learn about forest planning would be to get on a mailing list for information from a forest that is going through the planning process. The Black Hills issues a newspaper to the public every few months that describes major stages, progress, and decisions in the revision.

Forest plan revision is expected to take about 3 years to complete. The Black Hills first forest plan was issued in 1983, so their first revision is due in 1993. The planning process began in summer of 1989 and the final draft is expected to be completed by spring of 1994. The forest plan revision progress chart shows the time frames involved for the major steps included in the planning process (fig. 1).

Although Forest Pest Management staff should be involved throughout the planning process, the most important stages for input are likely the initial public comment period, the analysis of management situation, development of alternatives, and estimation of effects of alternatives. Research staff may also want to get involved, but at a less intensive level. Getting involved in the public comment periods, providing technical assistance for new models, and working cooperatively with Forest Pest Management personnel on issues and information needs are likely the most efficient use of time for research staff.

Forest plan revision involves incremental planning. In other words, the forest does not start at ground zero and try to analyze everything. The starting point is the current forest plan. Once the forest staff has identified potential revision topics, they involve the public to find out whether there are additional issues or information that need to be included in the planning process. The public comment period is an important point and opportunity for providing input on pest management information and concerns. There seems to be a misperception by many that public comment is exclusively for external publics, such as environmental groups, landowners, and timber industries. However, the forest needs input, especially on new technical information and management practices from their internal publics as well, that is, Forest Service employees.

Comments need to be written to insure they will be considered during the planning process and must meet the deadline specified. Although input from Forest Service staff is welcome throughout the planning process, the importance of the initial public comments is that this is what the major issues and final revision topics are developed from. The selected revision topics are what the planning team will be focusing the

majority of their efforts on. The planning team is generally resistant to including additional topics later in the process, especially if it requires a lot of time or backtracking. If forest health or pest management is not identified as an area needing revision, the pest management input needs to be incorporated into other appropriate topics as much as possible. For the Black Hills, of the six selected revision topics (fig. 2), the most likely places to include pest input are under the biodiversity topic and the topic on lands not suitable for timber harvest and allowable sale quantity. Note that revision topics are selected primarily on the basis of whether a change in management direction will cause a major change in the production of goods and services on the forest.

Issues raised by external publics tend to include short-term, current problems and controversial topics currently in the news and political arenas. For example, the water yield management topic was identified as an issue because of the drought that began about 1988 and the resulting controversies on how to supply adequate amounts of water to Rapid City. The biodiversity topic responds to a national issue, primarily triggered by controversies in the Pacific Northwest over old growth and the spotted owl. Notice that even though the Black Hills does not have old growth in the sense that the Pacific Northwest does, and there are no known old-growth dependent wildlife species in the Black Hills, the issues of old growth and biodiversity for wildlife habitat will affect the way resource management is done on the Black Hills.

Issues or problems that are not highly visible to external publics and forest staff can be overlooked in the planning process. The mountain pine beetle, which is the most visibly destructive pest in the Black Hills, has not been in widespread outbreak status for about 10-15 years, so pest management was not recognized as a forest issue. During development of the first (current) forest plan, the effects of mountain pine beetle were recognized as an issue and direction for silvicultural treatment are generally included. The current plan directs intensive timber harvesting activities for ponderosa pine. The effectiveness of that management direction, i.e. preventative thinning and harvesting, generally is not currently recognized by a lot of people and there is potential for increasing stand susceptibility and spread of mountain pine beetle in response to pressure to develop large areas of old growth and habitat linkages for wildlife. Most forest plans likely do not include as much direction pertaining to pest management as the Black Hills Plan does. By way of contrast, pest problems in the Blue Mountains of Oregon generally were not considered in their original forest plans, are currently described as devastating the ecosystem, and are driving a lot of discussions of forest health in Washington, DC. But forest health has not yet reached the level of national recognition among external publics and many forest personnel as the biodiversity and old growth issues have. The problems of the Blue Mountains are not yet generally seen as being relevant to the Black Hills.

Few comments were received by the Black Hills National Forest pertaining to forest pest management, but they span the spectrum from do nothing to intensive management for bark beetle control (fig. 3). These comments were easily dismissed by forest personnel as not requiring major changes in direction that would affect levels of goods and services. In other words, forest personnel perceived that current direction in the forest plan is adequate, but perhaps it could be better implemented at the project planning level. Thus, insect and disease issues and comments were lumped into the category of implementation topics (fig. 4).

Some issues can be designated as amendment topics. These are needed changes in the forest plan that do not significantly affect levels of goods and services. Gypsy moth eradication and suppression was identified as a topic for amendment. Even though it was not addressed in any of the public comments, Forest Pest Management in Region 2 pushed for this change because there was no mention of this management activity in the original forest plan, and the introduction and establishment of gypsy moth in the Black Hills has become a greater possibility in the past few years. As a result, an amendment was drafted and is now part of the existing forest plan. Amendments to the forest plan can be done at any time a need is identified and do not require waiting for a revision to take place. A number of changes in pest management direction that arise from new technical information or changes in environmental

situations likely can be handled through forest plan amendments if these are brought to the attention of staff on affected forests.

Research topics are identified for issues where insufficient information is available to make reasoned decisions. Researchers need to listen to and respond to issues identified by the forest as needing study so that management direction can be developed to address these issues in the future. By working with the forest at this stage, forest personnel are more likely to be receptive to incorporating changes suggested by researchers in later amendments and revisions.

When providing input for forest planning, it really needs to be formulated in a way that addresses the broad-scale level of management direction encompassed by forest-level planning. When considering information to incorporate into forest planning, one needs to think about how it will address three questions (fig. 5). First, will it change management area designations? For example, if a pest problem is chronically affecting an area such that management goals can not be met, the management emphasis may need to be changed. If a stand designated as fiber production emphasis is affected by a large root rot center, for instance, that severely reduces tree growth and causes extensive tree mortality, and if harvesting activities aggravate the problem, it might be better to consider managing the area primarily for wildlife habitat or some other suitable use. Note that changing management area designations can significantly affect the mix of goods and services produced.

Secondly, will new knowledge significantly affect yield projections in the Prognosis Model? This will affect the resulting determination of allowable sale quantity (ASQ), the number that some people refer to as timber targets. Forest staffs are anxious to get any products of this nature that will improve their timber production estimates; however, pest models need to be available and calibrated for the forest in question at the time forest planning begins. The silviculturist on the Black Hills began modeling with the Black Hills version of Prognosis in early 1990, and after several hundred computer runs and about 20,000 pages of information, completed the task in spring of 1992, just as the analysis of existing management situation was being completed. If it takes research and development an optimistic 2 years to develop a pest submodel for a given area, then the study needs to begin at least 5 years prior to the revision due date in order for it to be available and useful to the forest in the upcoming planning period.

The third question is: does new information change recommended standards and guidelines for management activities? In other words, are there new ways of doing business that need to be specified to insure their application in order to protect resources, insure good land stewardship, or promote efficient, economical, and sound resource management and production of goods and services? Since forest managers do not specifically manage pests as a resource, standards and guidelines must be developed in relation to resources with measurable outputs, such as timber, recreation, and wildlife habitat. Also keep in mind that decisions must be implementable, so technologies must be available and operational at the time of the final Forest Plan document.

Standards and guidelines should be written in a way that identifies measurable outputs. For example, acres treated by thinning and harvesting and acres in low, medium, and high risk for mountain pine beetle are measurable indicators of the level of management activities. Outputs must be monitored in order to determine how well standards and guidelines are being applied, how well forest plan objectives are being met, and the effects of management practices. Monitoring requirements for insects and diseases are particularly weak in current forest plans. Most specify something like: aerial surveys and ground checks will be conducted to determine when pest outbreaks are imminent. The development of monitoring standards and methodologies for forest plans is an area needing greater input from Forest Pest Management. Monitoring is intended to determine when and what changes are needed in the forest plan, whether through an amendment, a revision, or better implementation at the project level. It can also identify problems needing research.

After the initial public comments are screened and synthesized, most of the information gathering and analysis aspects of forest planning are conducted during the analysis of management situation, development of alternatives, and effects of alternatives stages. This is where Forest Pest Management personnel can be helpful in pulling together data, drafting management strategies, and reviewing documents to identify conflicts with other disciplines and management goals. The Regional Guide in Region 2 specifies five items as a minimum to be done in the area of integrated pest management (fig. 6).

The Rapid City Service Center currently is working on a hazard-rating map for mountain pine beetle using information in the current resource inventory database. A computer program to hazard rate for specific pests that is incorporated into the inventory database system is necessary in order to do this very efficiently. There has been some difficulty getting started on this analysis, and a problem of map scale still remains. The forest is represented by 82 quads with about 1000 management areas per quad. Also, only about 60% of the ponderosa pine stands have Stage II inventory data available. Access to the database is generally restricted to a few people in the Forest Supervisor's Office who know how to operate the software and query the system. After much discussion as to feasibility, the Rapid City Service Center was able to get a copy of the most recent update of the forest database and version of Oracle software loaded onto the Data General system at the office, so that work on the data processing can proceed independently of the forest staff. This was possible because the Rapid City Service Center has access to a huge Data General system with lots of vacant space. Once the needed information is extracted, then it needs to be run through the GIS-like system at the Forest Supervisor's Office to generate a map. This map would illustrate the current situation.

Ideally, additional maps should be generated to display hazard following treatment under various proposed alternatives. It is not yet clear whether this can be done without massive amounts of hand calculations, because the Prognosis and Forplan models do not provide output in a format similar to the database that contains current stand inventory information. Also the Black Hills set-up of the Forplan model, which evaluates stand treatments, does not use basal area as an input or output value, but this is a major factor used in calculating stand hazard for mountain pine beetle. Rapid City Service Center staff intend to pursue any possibilities for hazard mapping following stand treatment for the 10-year time period covered by the plan revision.

A major obstacle to incorporating pest information during the Black Hills revision process was the lack of useable pest subroutine models. Models have been developed for mountain pine beetle in lodgepole pine, but not for ponderosa pine, which is the predominant tree species in the Black Hills. The need for a bark beetle model for ponderosa pine was brought to the attention of the Methods Application Group, and they plan to develop such a model. The model will not be available in time for this round of forest plan revision for the Black Hills National Forest, but should be available in time for the third decade of planning that will start around 1999 or the year 2000. When suitable models are available for major insect and disease pests, this is one of the easiest ways to incorporate significant pest information into the planning effort. Forests are anxious to get any information that will allow them to more accurately estimate growth and volume for determining ASQ levels.

The Black Hills is just now beginning to formulate alternatives, so experiences to share are limited from this point through the remainder of the planning process, which is expected to take about another year.
The role of Forest Pest Management likely will be helping to review and develop any needed changes in standards and guidelines, and helping to determine effects of the various alternatives during these stages. The Black Hills is starting to develop various alternatives based upon emphasizing different themes (fig. 7). There is not an alternative corresponding to each revision topic, but for those revision topics that are not addressed directly, they will be included as evaluative criteria for each alternative.

In summary, it is important to emphasize that forest planning is an opportunity to get new information and technology incorporated into the way National Forests manage their resources. It is important that people with pest management knowledge be included in the process and work closely with the

interdisciplinary forest planning team. This allows input to be provided as planning is developing. Because of the complexity of the process and issues, it can be frustrating at times to not have one's input incorporated into the documents, especially when conflicting recommendations are being promoted by specialists in other disciplines, who have competing interests. Sometimes it helps to have an advocate in the Regional Office who is not closely involved in the planning process, but who can push certain requirements or viewpoints during reviews of planning progress. I think the role of Forest Pest Management could be summarized as being a resource for information, helping to gather and analyze relevant pest information, and providing recommendations for management activities related to reducing levels of destructive pests. Researchers need to be involved in pest model development and validation that is tied to Prognosis, development of new technologies that can change standards and guidelines for management activities, and responding to identified information gaps and management needs.

FIGURE 1: FOREST PLAN REVISION PROGRESS CHART

FIVE-YEAR EVALUATION OF EXISTING PLAN
SUMMER 1989

PUBLIC COMMENT PERIOD
ENDED FEB. 1990

REVIEW OF PUBLIC COMMENT
SPRING 1990

DEVELOP PURPOSE AND NEED FOR REVISION
SUMMER 1990

ANALYSIS OF THE EXISTING MANAGEMENT SITUATION
SPRING 1992

DEVELOP ALTERNATIVES
SUMMER 1992

ESTIMATE EFFECTS OF ALTERNATIVES
FALL/WINTER 1992/3

DRAFT PLAN AND EIS
SPRING 1993

PUBLIC COMMENT
SUMMER 1993

FINAL PLAN AND EIS
SPRING 1994

FIGURE 2: REVISION TOPICS SELECTED

- CHANGES WHICH WOULD PRODUCE MAJOR EFFECTS ON THE MIX OF GOODS AND SERVICES THE FOREST IS PRODUCING, SO THAT THE ANALYSIS LEADING TO THE ORIGINAL PLAN IS NO LONGER VALID, AND TOPICS WHERE THE INTENSITY OF THE ISSUE OF MANAGEMENT CONCERN IS VERY HIGH.

1. BIOLOGICAL DIVERSITY
2. WATER YIELD MANAGEMENT
3. LOCATABLE MINERALS MANAGEMENT
4. LEASABLE MINERALS (OIL AND GAS) MANAGEMENT
5. LANDS NOT SUITABLE FOR TIMBER HARVEST AND ALLOWABLE SALE QUANTITY
6. BEAVER PARK RARE II AREA

FIGURE 3: PUBLIC COMMENTS/INSECTS AND DISEASE

* DO NOT USE TAXPAYER MONEY TO REMOVE INSECT DAMAGED AND DEAD TREES.
* ENCOURAGE PUBLICITY ON HOW TO KEEP THE FOREST OUTSIDE AND INSIDE THE NATIONAL FOREST HEALTHY.
* CONTINUE TO THIN AREAS INFESTED WITH MOUNTAIN PINE BEETLES TO IMPROVE THE HEALTH OF THE TREES AND CONTROL THE BEETLES.
* THE PINE BEETLE WILL SHORTLY YIELD THOUSANDS OF ACRES WHICH WILL NEED "CRISIS" MANAGEMENT.
* INSECT AND DISEASE SUPPRESSION SHOULD FOCUS ON NATURAL CONTROL AGENTS AND MECHANISMS.
* DON'T LET OUR GUARD DOWN AGAINST BEETLES.
* IPS BEETLES ARE ON THE INCREASE DUE TO DROUGHT.
* PRESCRIBED BURNING IS STRESSING TREES AND MAKING THEM SUSCEPTIBLE TO IPS.
* IN AREAS OF HIGH IPS CONCENTRATION, USE WHOLE TREE HARVESTING CENTRALIZING THE SLASH, AND PLACE IPS TRAPS.

FIGURE 4: OTHER TOPICS

AMENDMENT TOPICS:	TOPICS THAT WILL NOT SIGNIFICANTLY ALTER THE LONG-TERM RELATIONSHIP BETWEEN LEVELS OF MULTIPLE USE GOODS AND SERVICES ORIGINALLY PROJECTED IN THE PLAN. GYPSY MOTH ERADICATION AND SUPPRESSION
IMPLEMENTATION TOPICS:	TOPICS WHERE THERE IS NO EVIDENCE THAT THE EXISTING PLAN DIRECTION IS NOT WORKING, BUT RATHER, THE PLAN HAS NOT BEEN FULLY IMPLEMENTED, AND TOPICS WHERE THE EXISTING PLAN PROVIDES ENOUGH FLEXIBILITY. INSECT AND DISEASE CONTROL PRACTICES: NO MAJOR OUTBREAKS OF INSECTS AND DISEASES ARE CURRENTLY PRESENT. EXISTING PLAN DIRECTION IS ADEQUATE TO PROTECT AGAINST FUTURE OUTBREAKS.
LEGISLATIVE TOPICS:	TOPICS WHERE LEGISLATIVE ACTION IS NEEDED TO ANSWER THE ISSUE OR CONCERN.
TOPICS FOR OTHER ENTITIES:	TOPICS WHERE THE FOREST SERVICE DOES NOT HAVE JURISDICTION.
RESEARCH TOPICS:	TOPICS WHERE NO DECISION CAN BE MADE AT THIS TIME BECAUSE MORE DATA IS NEEDED TO FULLY UNDERSTAND THE ISSUE.

FIGURE 5: QUESTIONS TO ADDRESS IN FOREST PLANNING

1. DOES IT CHANGE MANAGEMENT AREA DESIGNATIONS?

2. DOES IT SIGNIFICANTLY AFFECT YIELD PROJECTIONS IN PROGNOSIS MODEL?

3. DOES IT CHANGE STANDARDS AND GUIDELINES?

FIGURE 6: R-2 REGIONAL GUIDE DIRECTION FOR INTEGRATED PEST MANAGEMENT

1. PREPARE HAZARD AND RISK MAPS OF PESTS OF CONCERN.
2. INCLUDE GROWTH AND MORTALITY PROJECTIONS FOR MEDIUM AND HIGH RISK STANDS, WHERE PEST MODELS ARE AVAILABLE.
3. IDENTIFY MITIGATION STRATEGIES AND TREATMENTS.
4. DEVELOP VEGETATION MANAGEMENT STRATEGIES TO MINIMIZE ENCROACHMENT, AND IDENTIFY AREAS WHERE PESTS CAN RUN NATURAL COURSE.
5. DESCRIBE EFFECTS OF PESTS ON MANAGEMENT GOALS FOR EACH ALTERNATIVE.

FIGURE 7: PRELIMINARY ALTERNATIVES DEVELOPMENT LIST

- DEVELOPED IN PART FROM REVISION TOPICS THAT MOST CONCERN THE PUBLIC.

* "NO CHANGE" ALTERNATIVE (STATUS QUO--EXISTING FOREST PLAN)

  UPDATED "NO CHANGE" ALTERNATIVE (HOUSEKEEPING CHANGES)

* RETAINS TIMBER SUPPLY (ALLOWABLE SALE QUANTITY)
* BIODIVERSITY THEME--DROPPED, INCLUDE IN EVALUATIVE CRITERIA
* MATURE FOREST THEME
* MAXIMUM TIMBER/MINERALS THEME--COMBINED WITH COMMUNITY DEVELOPMENT
* COMMUNITY DEVELOPMENT THEME--COMBINED WITH MAXIMIZE TIMBER/MINERALS
* ECONOMIC AND/OR FINANCIAL EFFICIENCY THEME
* FEATURED SPECIES THEME--REQUIRED BY LAW
* RETURN TO PRE-1983 THEME--DROPPED
* RETURN TO LATE 19TH CENTURY THEME--DROPPED
* HEALTHY TREES THEME--DROPPED
* RECREATION OPPORTUNITY THEME--MIGHT GET DROPPED AND INCLUDED IN EVALUATIVE CRITERIA

INTEGRATING FOREST HEALTH INTO FOREST MANAGEMENT PLANNING: A BUREAU OF INDIAN AFFAIRS PERSPECTIVE

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Forest health considerations play an important role in all our forest land management activities. This is particularly true for reservation forests in the Pacific Northwest where over three million acres are located on the eastside of the Cascades. These lands, which were once dominated by ponderosa pine as the major component, have moved toward climax species as seen in the recent Continuous Forest Inventory "trends output" for the eastside reservation forests. This change has increased the occurrence of scattered insect and disease problems in these forests. When you add to these conditions the recent drought, reservation stand conditions are at a point where insect and disease problems are at outbreak levels and where questions are being asked about how current planning will meet forest management goals and objectives given these current conditions. These questions are being asked not only in the Northwest but on reservations throughout the United States and Canada as expressed during the 1992 National Indian Timber Symposium.

The perspective will focus on Indian reservations from the Pacific Northwest with the Bureau of Indian Affairs (BIA) regulations, the Warm Springs Integrated Resources Management Plan (IRMP), the Environmental Assessment (EA), and the Forest Management Plan (FMP) as the primary documents of discussion.

The Bureau of Indian Affairs' process for integrating forest health into forest management planning is presently changing to be more flexible and responsive to the pest problems while meeting the Tribal forest management goals and objectives. Again, this past 7 years of drought in the Northwest has accentuated the forest pest problems on many reservations. This has forced these reservations to update existing management plans or develop new plans with more emphasis on forest health considerations. In addition it has lead to more refined silvicultural prescriptions which address in greater detail pest problems, their interactions, and more innovative treatments.

In my presentation today I will share with you the present planning process and requirements for integrating forest health beginning with the forest management plan, then discuss how forest health is integrated on the Warm Springs Reservation, and finally, describe some adjustments being made by reservations in the Northwest.

The present forest health integration process begins with the forest management plan and its environmental assessment as required by Bureau of Indian Affairs regulations and manuals[1]. The forest health requirements are first covered in the "Forest Protection Program Implementation Plan" section titled Insects and Diseases. This section states the responsibilities for monitoring and controlling insect and disease activities. Secondly, in most forest management plans, specific insects and diseases, related stand conditions and treatments are covered in the silvicultural prescription section in the Timber Management Program Implementation Plan - Silvicultural Guidelines. These are general silvicultural prescriptions based on habitat type or plant association and are also the primary means of incorporating forest health into the planning process on a stand level.

In the process of developing the forest management plan, the Tribal Council and the tribal public first set goals and objectives for management of their resources. Any questions they might have are discussed and answered, especially those concerning forest and stand conditions and forest health. All plans or plan adjustments require tribal as well as BIA approval. The plan as stated in the manual is to be "responsive to tribal goals and objectives and must be supported by tribal resolution."

[1] 53 BIAM Supplement 2, Forest Management Planning.

With this process as a basis, the Warm Springs Indian Reservation completed an Integrated Resources Management Plan (IRMP) for the Forested Area and Forest Management Plan this year. The integration process for all resources began 2 years ago with the insect and disease sections of the FMP and EA, and has expanded to a forest health program which includes a forest health coordinator and a forest health technician. Forest health issues began in the EA and were addressed as forest health. Pest data were sparse and limited to Continuous Forest Inventory plot summaries. At the IRMP stage, forest health goals, objectives, and the desired future condition were developed, discussed, accepted, and published in a field guide. In the Silvicultural Prescription section, Pest Management Strategies were developed.

In the process of incorporating forest health into the IRMP, questions were raised concerning the concept of forest health as compared to the previous designation as forest protection and pest management. The primary question raised by other resources was whether insect and disease attacks would affect the forest ecosystem as a whole or just kill trees and leave other components such as soils, water, and wildlife intact. By the end of the planning period, this plan looked at the forest as a multiple resource base and analyzed on an ecosystem level.

The Warm Springs Reservation is now in the implementation stage of the IRMP/FMP. The forestry timber sale program is proceeding using the best management practices standards and guidelines, the Geographic Information Systems (GIS) with mapped resource emphasis zones, and approved silvicultural prescriptions and pest management strategies. Even with the field guides, maps, and strategies, questions arise about forest health problems in relation to other best management practices. For example in the IRMP long-term, productivity "habitat clumps" are required in even-aged, final-harvest blocks. These clumps are areas maintained in the preharvest condition with no harvest in them, and cover 2.5 percent of a block. Field crews had several questions about where to install these clumps when dealing with varying degrees of dwarf mistletoe infections in the area. These questions were discussed and some adjustments are in the process of being made. The Warm Springs approach is flexible and will continue to be in order to treat pest problems while achieving management objectives.

The completion of the IRMP/FMP was an interesting experience. It emphasized that integrating forest health into planning in the BIA is to explain and discuss forest health issues with the landowners - the Tribal public, the Tribal Committees, and the Tribal Council. The question about "habitat clumps" was asked by a Timber Committee member who works in timber sale administration. Incorporating forest health issues into the planning process required a discussion of the cause and effect relationship of the forest condition to the increase in forest pests and how natural balance and sustainability was achieved in the forest ecosystem. Explanations and field trips were used to develop a forest health understanding to tribal members with very diverse backgrounds ranging from ex-loggers or forestry employees to people involved in human resource professions. They are very interested because this land and forest is their home, hunting and gathering areas, and provides income to run their government.

With the increased drought and pest problems, many reservations on the eastside of the Cascades are updating or writing new management plans with more emphasis on forest health issues. Not all of these reservations suffer to the same extent but all suffer an increase in forest pest problems. Each reservation is developing its own approach. While most are writing or updating their forest management plans, others are developing more refined silvicultural prescriptions. All updates are using the interdisciplinary team approach, getting varied responses from wildlife and other resources. Most are spending time and money educating the tribal public about forest health. For example, the Colville Reservation in eastern Washington took the Tribal Council to the Blue Mountains in eastern Oregon to see and discuss forest health problems and possible remedies. The Warm Springs, Flathead, Yakima, Spokane and Colville forestry departments have taken their councils on reservation field trips to discuss several forest health issues.

A particular issue which has had many diverse responses is dwarf mistletoe and its treatment. One reservation is in the process of adjusting the plan by removing uneven-aged management restrictions, especially in dwarf mistletoe infected areas in the pine types. Still other reservations are developing more refined silvicultural prescriptions which can meet the Tribal objectives and reduce dwarf mistletoes.

In general, most reservations are treating the dwarf mistletoe infected areas using even-aged silvicultural prescriptions. Earle Wilcox, who initiated several uneven-aged stocking studies and stressed uneven-aged

management as a forester with the Bureau, after seeing dwarf mistletoe infected stands on an eastside reservation, once said that uneven-aged management just can't be done on some areas. Each reservation is developing different long-term alternatives towards meeting desired future conditions in the dwarf mistletoe infected stands. The diversity of response shows the view of management planning as flexible within the Pacific Northwest.

A forest health data base would provide the information to make these management decisions and improve the process of integrating forest health into forest management planning. It is important to know what the pest problems are and where they are. The Northwest area reservations are in the process of developing and implementing spatial surveys specifically for forest pests. For example, the Warm Springs Reservation forest health program is mapping dwarf mistletoes in the pine type and root rots in the high-elevation areas.

Also in response to the need for more pest data for management planning,the Continuous Forest Inventory permanent plot system has been updated on some reservations to include pest information by tree or plot. Besides furnishing spatial pest information, growth and yield data from stratified pest plots can be calculated and compared to non-problem plots.

With this data, many reservations are using GIS (Arc/Info) for storage, tracking, relating tabular data to map data, and most importantly analysis and prioritization. The Arc/Info program's ability to overlay many layers allows the planners to quickly investigate several treatment alternatives using spatial pest data and management objectives, and subsequently make more informed decisions.

Forest health problems have impacted the Northwest reservations such that planning has changed from stand-level to landscape-level priorities and treatments. For example, timber sale area priorities on the Colville Reservation are based on forest health conditions. In like manner, silvicultural prescriptons have expanded their focus to forest health problems. These prescriptions continue to be reformed based on monitoring and evaluation. Included in several FMPs are underburns in specific areas for forest health reasons as well as fuel reduction.

In summary, the BIA process of integrating forest health into forest management planning will be a flexible process where plans can be kept in "three ring binders," a living document, and easily updated. The primary means to make it run smoothly is to provide the landowners with information about forest health and its relation to the forest ecosystem so they can make informed decisions. From there, forest health issues can be discussed, incorporated, and implemented throughout the entire forest planning process.

FOREST HEALTH IN SUSTAINABLE ECOLOGICAL SYSTEMS

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Sustaining Ecological Systems, SES, is the title used in the Northern Region for our Regional management philosophy, known nationally as Ecosystem Management. It is, in reality, a direction in which we have been headed for many decades, perhaps since the appointment of the Forest Service to manage public lands for sustained yield (Monnig and Byler 1992). At one time "yield" referred primarily to wood products. The science of forest management has evolved as has human society. Our expectations of forests have changed. We expect them to play a role in sustaining ecological systems for the purpose of **sustaining ecosystem productivity and resilience.** Our expertise has expanded as well and tools such as GIS give us the ability to look at forests at great expanse or in great detail. As a result, we are able to start answering questions posed by visionaries such as Aldo Leopold and Gifford Pinchot nearly a century ago.

By looking at forests as ecosystem components we will better understand the ways in which we can work constructively to sustain ecosystems and sustain ecologically appropriate yields of the variety of "products" from forests including biodiversity, recreation and aesthetic values, hydrologic values, and atmospheric renewal as well as the more traditional, wood and big game. An ecosystem, defined as the sum of the biological species, the physical environment and their combined processes and functions, is complex beyond our understanding. Even forests are too complex to be totally understood. So how in the world do you manage something you can't understand?

Our focus will be to maintain natural ecosystem processes and functions across the variety of spatial and temporal scales we are able to analyze. A mouthful, to be sure, but, in fact, quite literally the objective. The approach is adaptive management. That is, as we have more or better information, we adjust. It is also inclusive. We can not look only at lands owned by the Federal or State governments. Administrative boundaries are not ecological boundaries. New partnerships are emerging among private and public land managers and among professionals in all fields of expertise with the common objective of sustaining ecological systems.

SO WHERE DOES FOREST HEALTH ENTER INTO THIS?

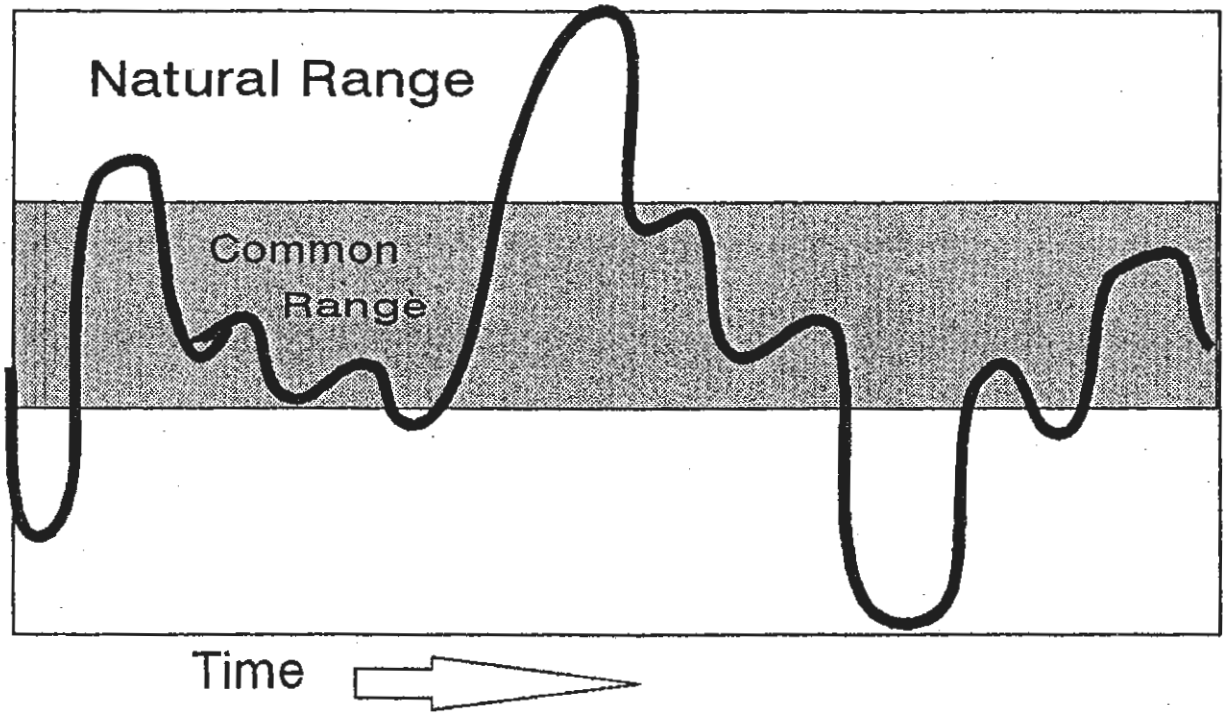
Forest health is a critical strand, inextricably interwoven in the fabric of forest ecosystem health. There are many ways to view forest health. The concept is intuitive, and like most intuitive subjects, opinions regarding the definition of forest health vary greatly. Human society has much at stake in forest health. Socially defined, healthy forests are expected to produce an even flow of goods and services. One social definition of forest health states: A desired state of forest health is a condition where biotic and abiotic influences on the forest do not threaten management objectives for a given forest unit nor or in the future (Knauer et al. 1988). This definition gives considerable flexibility in describing health for a given forest. If the desired objectives can be reached by the forest, then it can be considered healthy. As products or amenity objectives change, the condition that is considered healthy in a forest will change as well.

Another way to view Forest health is as a scientifically substantive phenomenon. Human health, like forest health, is intuitive but cannot be precisely defined in such a way that it accurately reflects health for more than one individual at a time. So it is for forests. Each is individual and functions somewhat differently from its neighbor. Just as we accept the variety in defining health for humans, we need to accept the variety in defining health for forests. This can be done by basing the definition of an ecosystem's health upon the qualities which provide sustainability for that forest ecosystem. This definition will focus on natural functions in forest ecosystems.

The primary differences between these two approaches are that products and amenities are the focus of the social definition and byproducts of healthy forest ecosystems in the ecological definition; and that sustained flow of goods and services from forests is tantamount to health in the social definition, even if the forest condition itself is not naturally (or otherwise) sustainable. The ecological definition emphasizes the natural sustainability of a healthy forest ecosystem. If we chose to manage for unhealthy conditions, as we often do, we have a baseline for health against which we can measure divergence from a healthy condition. An analogy is the smoker who chooses to undertake actions (smoking) which reduce his or her lung capacity. Should healthy lung capacity now be measured in terms of the smoker's lung or would a baseline derived from non-smokers better define healthy lung capacity?

The significance of attempting to manage outside of the range of natural conditions is particularly evident in situations such as the Blue Mountains of Oregon and southeastern Washington (Gast et al. 1991) and in the Coeur d'Alene basin of northern Idaho (Hagle et al. 1992). These landscapes are undoubtedly just "the tip of the iceberg". The cost (both economic and environmental) of managing outside the natural range are also probably higher than those of managing within the natural range but outside the common range (Figure 1). This range has both spatial and temporal dimension.

Figure 1. Natural variability for ecosystem parameters through time. Common and Natural ranges can be identified.



Forests are ever-changing. Conditions that exemplify health in a forest change as well. Two primary factors in forest change are succession and disturbance functions. Forest succession and disturbance functions work interactively in fairly predictable patterns. Both the mix of successional stages, which is an indication of the general condition of a forest, and the patterns of disturbance functions describe the status of forest health within the context of successional patterns. Neither can describe forest health without the other.

Disturbance functions, as presented by Noss (1986), are fire, insect herbivory, disease, floods, windfall, etc. Like succession, disturbance follows predictable patterns in healthy forests. And like succession, it

is inevitable, even in unhealty forests. Typifying healthy successional and disturbance patterns is the first step to defining health for a forest.

FOREST HEALTH is a condition typified by succession and disturbance functions occurring within the natural range amplitudes and periodicities. They provide for a natural rate of nutrient and energy flows within forests.

CHARACTERIZING INSECT AND PATHOGEN DISTURBANCE FUNCTIONS

Several authors have discussed means by which to describe the natural range of amplitudes and periodicities for successional stages and fire (Arno 1980) (Gruell et al. 1982)(Steele et al. 1986) (Noss 1986). Methods used to describe fire patterns suggest approaches to describing insect herbivory and disease patterns. Frequency and "patch size" are recommended attributes for describing fire patterns (Cooper 1961)(Harris 1984)(Pickett, 1980). They are also important attributes of insect and pathogen-caused disturbances (Veblen et al. 1991). Fire behavior varies greatly according to vegetation and dead fuel characteristics as described in Fuel Models (Fischer 1981)(Anderson 1982). Similarly, insect and pathogen-caused disturbances will very according to vegetation characteristics. For example, root disease may produce large patches in forests devoid of mature trees or a single-tree thinning effect depending on the mixture of tree species on the site. An equally simple example is seen in Mountain pine beetle behavior (Peterman 1978).

Fire behavior is further described by fire hazard which brings in physigraphic and climatic factors. Again, the situation is parallel for insects and pathogens as is represented by risk and hazard models for a variety of such agents.

We understand a great deal about the way in which many insects and pathogens interact with vegetation and environmental factors. The results of these interactions are largely predictable. Thus descriptions of the insect and disease functions relevant to forest health are within our grasp.

AN EXAMPLE OF FUNCTION

For example, one such description would be relative to an extensive tract of mixed, mostly lodgepole pine and subalpine fir forest, subalpine fir habitat type group on the east side of the Bitterroots, north end of the valley. Here the successional stages are mixed in a mosaic small-patch pattern. The mostly lodgepole pine overstory has an abundance of subalpine fir in the understory. In some patches, mature subalpine fir, many with fire scars, are reaching a stage of decadence in which root and butt decay are causing trees to break off and form building piles of fuel. Some of the older patches of lodgepole pine, which are well-spaced and often fire-scarred, have reached diameters that support mountain pine beetle brood production. These are attacked and killed in patches which expand until younger, smaller diameter trees are all that remains in the vicinity. Nearby, jackstraw stems of lodgepole pine have formed a jumble; the mountain pine beetle gallery patterns still barely discernible on the prone stems. Sapling subalpine fir push their way up through the jumble. Patches of lodgepole pine and subalpine fir seedlings and saplings, a few to a fraction of an acre in size are found as another piece of mosaic puzzle.

Imagine how fire behaves in this mosaic of structures. Most of the area at only one time, is occupied by the relatively open stand of lodgepole pine with young subalpine fir in the understory. Here the fire tends to burn cool, creeping along the ground, killing the young subalpine fir. The fire misses some of the ground, leaving some of the young subalpine fir to mature or be taken in the next fire. Some of the larger subalpine fir, missed by earlier fires, are scarred but survive this fire as well. Here, decay fungi will take advantage of the aging trees and increase in air exchange caused by the scar. They will be able to increase their activity. As the fire moves into patches of accumulated fuels, it burns a bit hotter, consuming much of the downed material and, perhaps a few around the "jackpots". But with the low fuels surrounding the concentrations, the fire will likely settle down fairly rapidly unless weather conditions are particularly conducive to crown fire. The patches of regeneration may burn through and be killed entirely, burn very

cool, killing only a fraction of the young trees; or escape the fire entirely. The relatively open canopy will favor lodgepole pine survival in these and the newly-created openings. In the underburned sections of the mosaic, subalpine fir regeneration will re-establish and take another shot at reaching seed-producing age.

In this case a mountain pine beetle function can be described simply as creating fuel aggregation which lead to a patchy stand structure and prolonged longepole pine cover in broadscale. There are, of course, other insect and pathogen functions which are readily identifiable in this description of a dynamic forest. Examining the spatial and temporal distribution of these and other functions across the landscape provides us with a natural range of conditions which can be used as markers for designing management at a broad scale.

WHAT TO DO WITH THIS INFORMATION:

If mountain pine beetle, as the example, is "controlled" in this forest; that is, if it is prevented from performing this function, change will continue to happen. The changes will produce a chain reaction of events which will yield a forest which may be quite different from the one encountered here; a sequence which is potentially lethal to species which evolved with the historic forest conditions.

Management will be designed to either allow the natural processes to proceed unhindered or to simulate (Hart 1990) one or more of the functions in the interest of preserving the whole while producing consumed and non-consumed products such as wood fiber or elk or watershed protection. Thus, forest management goes on but with the umbrella mission of sustaining ecological systems.

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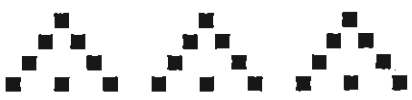

PANEL: LOG IMPORTS AND INTRODUCED FOREST PATHOGENS INTO WESTERN NORTH AMERICA

Moderator: Gregory M. Filip

Participants: Borys M. Tkacz, Donald J. Goheen, Gregg DeNitto, and James F. Fons

INTRODUCTION

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I would like to welcome you to the panel on "Log Imports and Introduced Forest Pathogens into Western North America." In mid- 1990, test shipments of logs from the Russian Far East were imported into the United States through Eureka, CA. These shipments were inspected using protocols developed jointly by the California Department of Food and Agriculture and the USDA Animal and Plant Health Inspection Service (APHIS). A number of insect pests had been previously identified on Russian logs imported into Sweden, China, Japan, and Korea. This prompted the USDA to temporarily ban additional log imports from Russia until completion of a pest risk assessment. In March 1991 the USDA Forest Service and APHIS convened a team of experts from North America, many of whom are here today, to assess the ecological and economic risk of importing pest-laden logs from Siberia and the Russian Far East to Western North America.

Two log shipments have been imported from New Zealand in late 1991 and early 1992. The first shipment contained radiata pine logs infested with insects and fungi. The logs had been treated with pesticides in New Zealand. The second shipment of radiata pine, which had been fumigated in New Zealand, was infested with *Sphaeropsis sapinea*. New Zealand also plans to export Douglas- fir to the United States. Radiata pine logs have recently been imported from Chile to the Pacific Northwest.

In April 1992, Oregon State University conducted a symposium on log imports and introduced forest pests into the Pacific Northwest. This three-day conference addressed such topics as why import logs into the Pacific Northwest; the risk assessment approach used by APHIS; the forest resources of Russia, New Zealand, and Chile and potential introduced pests; and concerns of managers of Christmas trees, ornamentals, and nurseries regarding foreign pest introductions. Today we have time only to briefly explore some of the topics addressed at the OSU conference.

PEST RISK ASSESSMENT OF THE IMPORTATION OF LARCH FROM SIBERIA AND THE RUSSIAN FAR EAST

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Background

There is an intense commercial interest in developing a long-term industry in the Pacific Northwest for importing and processing logs from Siberia and the Russian Far East. Russia has the largest forest resources of any country in the world. A number of U.S. firms are competing with Japan and other countries for timber rights to this resource. Various social, political, and environmental issues have impacted management and marketing of timber resources, reducing timber availability and causing economic effects in the Pacific Northwest. Log importation from Siberia is viewed by some as a possible means to address that problem.

Two small shipments of Russian logs were imported into the U.S. in mid-1990 and were processed under a protocol developed jointly by the California Department of Food and Agriculture (CDFA) and the Animal and Plant Health Inspection Service (APHIS). The test shipments were inspected upon arrival in Eureka, CA and two exotic pests were discovered. The scientific community and the Forest Service expressed concern about risks of introducing potentially damaging insects and disease causing organisms on unprocessed logs from Russia. This prompted the U.S. Department of Agriculture (USDA) to temporarily ban additional log imports from Russia until a Pest Risk Assessment could be completed.

There is a great similarity between the climate, forests, fungi, nematodes, and insects of Siberia and the Russian Far East and the Pacific Northwest. These similarities are mostly at the family or genus level with species being restricted to one area or the other. When similar species occur in both areas, they often exhibit distinct genetic strains with differing biologies or virulence. The associations between pests and their hosts have developed over millions of years. When trees from one region are exposed to insects or pathogens from another similar region, the evolved defenses of the tree may not be effective against the new organisms. Other ecological constraints on population growth, such as antagonists, predators, or pathogens, may not be effective in limiting populations of exotic organisms. The results of introductions of exotic organisms may be expressed as severe pest outbreaks with economic and ecological disruption in forests.

Purpose of Risk Assessment

The purpose of the Pest Risk Assessment was to:

1. Identify exotic organisms that have the potential of becoming pests that may move with unprocessed logs from Siberia and the Russian Far East;

2. Assess the potential of colonization of groups or individual pests during the importation, processing, and utilization of the logs; and

3. Assess the relative potential impacts of the identified organisms that may become established.

Core Team

APHIS determined that the nature, complexity, and scope of the potential risk associated with importation of logs from Siberia required additional assistance to complete a comprehensive assessment. As a result, APHIS asked the Forest Service to identify and develop the information necessary to make a decision about regulating log imports. In response, the Forest Service formed a Pest Risk Assessment Core

Team to scientifically assess the risks posed by exotic pests and determine the probable significance of their introduction. The Core Team assembled advisory groups of scientists and specialists from universities, Federal laboratories, State and Federal regulatory agencies and Canada to help them on this project.

Once the advisory groups were assembled, two workshops were conducted. The first workshop was attended by entomologists and pathologists and determined the organisms that posed a risk and assessed the overall risk of importing larch from Russia. The second workshop was attended by entomologists, pathologists and economists and determined the economic effects of a possible introduction of pests from Russia.

Case Histories of Pest Introduction

While it is impossible to say how many exotic organisms are imported across national boundaries without becoming established in their new environment, there are sufficient examples of exotics becoming major pests to conclude that introduction of exotic organisms carries considerable risk. Six case histories were reviewed during the Pest Risk Assessment. Five of the pests were introduced into North America: the European gypsy moth (*Lymantria dispar*), chestnut blight fungus (*Cryphonectria parasitica*), Dutch elm disease fungus (*Ophiostoma ulmi*), Port-Orford-Cedar root disease fungus (*Phytophthora lateralis*), and white pine blister rust fungus (*Cronartium ribicola*). Moreover, all but the gypsy moth were unknown pests in their native habitats. The sixth case described the pine wilt disease, which resulted from the introduction to Japan of a North American species, the pinewood nematode (*Bursaphelenchus xylophilus*). These case histories provided a framework for the assessment of the potential impacts from new introductions.

Risk

Risk is a function of the probability of pest establishment and the consequences of establishment.

Probability of Pest Establishment:

Pest with host at origin:

1. Determine the probability of the pests being on, in or with the imported commodity at the time of importation.

Entry potential:

1. Determine the probability of the pest surviving in transit; and
2. Determine probability of the pest being detected at port of entry under quarantine procedures.

Colonization potential:

1. Determine the probability of the pest coming in contact with adequate food resource;
2. Determine the probability of the pest coming in contact with appreciable environmental resistance;
3. Determine the ability of the pest to reproduce in the new environment.

Spread potential:

1. Determine ability of the pest to spread beyond the colonized area; and
2. Estimate the range of probable spread.

Consequences of Establishment:

Economic damage potential:

1. Determine the economic impact if established, including the cost of living with the pest.

Environmental damage potential:

1. Determine the environmental impact if established.

Selection of Pests for Assessment

For this risk assessment, time and data were insufficient to evaluate the risks posed by every one of the hundreds of pests that have been identified on larch in Russia. Moreover, previous experience indicates that it is quite possible that an insect or disease organism that is of little consequence in Siberia and the Far East, or an undiscovered organism, may be disastrous once it is introduced into North America. The uncertainty of predicting which organisms may be introduced and the lack of data dictated that the focus of the risk assessment be directed to representative species from the hundreds of potential pests. These representative species were selected based on their perceived high potential risk, the availability of data, and their location on the logs. For example, rather than trying to investigate every bark beetle that could be introduced by way of logs imported from Russia, several *Ips* beetles and a *Dendroctonus* were selected as representatives. Conclusions about the likelihood of introduction, potential damage, and possible mitigation measures in these representative cases should apply to other species or even unknown species of bark beetles.

Grouping of Organisms

The selected organisms of concern were grouped into three categories:

1. Those that could hitchhike on logs (e.g., egg masses deposited on bark, infected foliage embedded in bark crevices or fissures);

2. Those associated with the bark and inner bark (e.g., bark beetles and weevils); and

3. Those that are found in the wood (e.g., wood borers, decay fungi, nematodes).

Individual Pest Risk Assessments

Risk assessment profiles were developed for those pests considered to pose the greatest potential risk to North American forests and for which information was available on their life cycle, ecology, invasion ability, and their potential ecological and economic impacts. Mitigation practices developed for these known pests were presumed to be as effective in combating similar unknown pests. Pinewood nematodes *Bursaphelenchus kolymensis* and *B. mucronatus*, larch canker fungus *Lachnellula willkommii*, exotic strains of the annosus root disease fungus *Heterobasidion annosum*, the Asian strain of gypsy moth *Lymantria dispar*, nun moth *Lymantria monacha*, and the spruce bark beetle *Ips typographus* (with its associated fungus, *Ophiostoma polonica*) were the six pests considered to represent the greatest known risk to North American forests in the event of an introduction. Detailed assessments of the potential consequences of introduction and establishment were prepared for these pests.

Potential Economic Impacts

The potential economic costs associated with the introduction of these pests are high (Table 1.). These costs would result from reduced yields caused by growth loss, increased mortality, defects in the host species, and increased management costs.

Table 1. Summary of Economic Costs to the Timber Resources of the Western U.S. from the Introduction of Selected Russian Forest Pests (unreserved timber for all ownerships).

		Economic Cost (millions $)		Affected Areas
Pest	Host	Best Case	Worst Case	(Millions)
Nematodes	*Pinus* spp.	33.4	1,670.0	26.7
Larch Canker Fungus	*Larix* spp.	24.9	240.6	0.8
Annosus Root Disease Fungus	*Pseudotsuga menziesii* *Larix* spp. *Pinus* spp.	84.2	343.9	9.6
Defoliators	*P. menziesii* *Picea* spp. *Abies* spp. *Tsuga* spp. Other	35,049.0	58,410.0	77.1
Spruce Bark Beetle	*Picea* spp.	201.0	1,500.0	8.1

Potential Ecological Impacts

The introduction and establishment of exotic pest organisms in North American forests could result in: tree species conversion, deforestation, wildlife habitat destruction, degradation of riparian communities, increased fuel loading, and loss of biodiversity.

Site Visit to Siberia

Members of the Pest Risk Assessment Core Team traveled to Siberia and the Russian Far East in July 1991 to meet with Russian scientists and foresters to discuss the pest risk assessment and to view forest pests, forest harvesting practices, and log handling procedures. This site visit confirmed that the selection of pests of concern was accurate and that concern about their possible introduction into North American forests was justified.

Conclusions

In summary, importing unprocessed logs from Siberia and the Russian Far East into North America can have serious consequences because of the potential for introducing exotic forest pests. Measures must be implemented to mitigate the risks of pest introduction and establishment.

Literature Cited

U.S. Department of Agriculture, Forest Service. 1991. Pest Risk Assessment of the Importation of Larch from Siberia and the Soviet Far East. Miscellaneous Publication No. 1495. Washington, DC.

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PATHOGENS POSING RISKS ON LOGS IMPORTED FROM RUSSIA TO THE WESTERN UNITED STATES

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Last year, I participated in a joint USDA Forest Service/Animal and Plant Health Inspection Service risk assessment of potential pests on larch (*Larix* spp.) proposed for importation from Siberia and the Russian Far East to the western United States. Our objectives were to:

1. Identify exotic organisms that could be introduced on unprocessed import logs;

2. Assess potential for these organisms to colonize logs, survive transit, and subsequently become established on North American tree species; and

3. Assess relative potential impacts of these organisms should they become established.

For our assessment, we relied heavily on a search of existing literature and consultation with American plant pathologists, entomologists, and ecologists with expertise and interest in the pest introduction issue.

Information about tree pests from the Russian Far East proved to be far from complete. Data on forest diseases were especially sparse. Pathogens of concern in a potential disease introduction situation include:

1. Those recorded in the literature that are known to occur in the log source country but not yet in the country that will receive the logs;

2. Reported pathogens that occur in both countries but which may be genetically different in the two regions; and

3. Unknown organisms or organisms that appear to be insignificant, innocuous, or even benign in their native ranges yet have the potential to become serious pathogens when introduced into new areas with different environmental conditions or with more susceptible hosts.

Since we had to provide as much hard data on pests as possible to decision makers, we had to concentrate our efforts on known organisms and could say very little about the third group in our risk assessment except to mention its existence. This is frustrating because many of the most serious introduced diseases of the past fell into this group prior to their introductions.

We compiled the following list of disease organisms that have been reported from Siberia or the Russian Far East on larch species:

Bursaphelenchus spp.
Hypodermella laricis
Meria laricis
Melampsoridium betulinum
Melampsora larici-capraearum
Melampsora larici-epitea
Melampsora larici-populina
Melampsora larici-tremulae
Melampsora populnea
Hymenochaete abietina
Lachnellula willkommii
Phacidiopycnis pseudotsugae
Columnocystis abietina
Fomitopsis officinalis
Fomitopsis pinicola
Ganoderma lucidum
Hapalopilus fibrillosus
Hirschioporus abietinus
Hymenochaete tabacina
Ischnoderma resinosum
Laetiporus sulphureus
Phellinus ignarius
Phellinus pini
Phellinus torulosis
Pholiota destruens
Polyporus squamosus
Armillaria spp.
Heterobasiodion annosum
Inonotus circinatus
Inonotus heinrichii
Inonotus tomentosus
Phaeolus schweinitzii
Polyporus osseus
Ophiostoma/Leptographium spp.

We ranked these pathogens, and prepared profiles on those for which we felt we had the most biological information (see USDA Forest Service Miscellaneous Publication No. 1495). We did particularly detailed evaluations that included economic analyses on three of the pathogens that we believed represented the greatest risks: *Bursaphelenchus* spp. (the pinewood nematodes), *Lachnellula willkommii* (cause of larch canker), and *Heterobasidion annosum* (cause of annosus root disease). Our analyses suggested that introduction of one or more of these pathogens could have tremendous economic, ecological, and social impacts similar to those caused by such introduced diseases of the past as chestnut blight, Dutch elm disease, and white pine blister rust.

We concluded that pests that might be introduced into the western United States on unprocessed logs from the Russian Far East and Siberia could indeed pose a significant risk to our forests. Unknown as well as reported pests could be involved. Both insects and disease organisms appeared to us to have considerable potential for colonizing logs, surviving on or in logs during transit, becoming established in American forests, and causing substantial damage. Because some of them could occupy the wood all the way to the centers of logs, pathogens may represent particularly great risks that would require especially drastic mitigation treatments.

NEW ZEALAND LOG IMPORTS
A PEST RISK ASSESSMENT

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United States timber companies are proposing to import New Zealand saw and veneer logs. Small volumes of logs were imported in the fall and winter of 1991. Because the USDA has no specific timber import regulations, the Animal and Plant Health Inspection Service asked the Forest Service to prepare a risk assessment that identified potential pests, estimated the probability of pest establishment, and estimated the consequences of their establishment. A team of five USDA personnel was assembled in spring 1992 to assess the risk of proposed importation of logs from New Zealand to the western United States.

The species proposed for importation are *Pinus radiata* and *Pseudotsuga menziesii*. It is estimated that about 95% of the importation would be *Pinus*. These logs would fill specific milling needs as a substitute principally for ponderosa pine.

Two shipments of logs had arrived at US ports prior to the assembly of the team. The first shipment had been machine debarked, sprayed with fungicide and insecticide, and washed free of soil in New Zealand. Logs were discharged in the ports of Seattle and San Francisco. Several potential pest organisms were found upon inspection. These included scolytid larvae, an unknown wood decay fungus, *Sphaeropsis sapinea*, *Ophiostoma pilifera*, *O. picea*, and *Leptographium procerum*. The second shipment was treated similarly with additional mitigation measures employed. This included hand removal of bark patches, removal of logs with fluted ends, and fumigation in the ship's hold with methyl bromide. Inspection of these logs identified only *S. sapinea* both at the port of entry and during milling.

Both of the tree species are native to the western US and were introduced to New Zealand in the nineteenth century. The significant pests on these two species in New Zealand have been introduced. New Zealand forest plantations are managed intensively with short rotations to maximize the economic return. Attempts are made to minimize pest losses and damage to trees to obtain this return. Plantations are inspected at least annually by Forest Health Officers of the NZ Ministry of Forestry for signs of ill health. Entomologists and plant pathologists with the Forest Research Institute provide additional support.

The USDA team collected information on the proposed importation including log origin, quantity, silvicultural practices, harvesting and shipping practices, destinations, and potential pests. The potential pests were determined by examination of literature and the New Zealand forest health data bases which were begun in 1961. The insects and microorganisms recorded from *P. radiata* and *P. menziesii* in New Zealand were compiled and placed in one of three categories. The categories recognized the occurrence of the organisms as either native to New Zealand, introduced to New Zealand from other than the US, or present in the US. From this compilation 16 insect species and 19 microorganisms were assessed. Seven organisms, 5 insects and 2 fungi, were selected from this group to be representative and were analyzed in detail. The seven organisms are: *Kalotermes brouni*, *Leptographium truncatum*, *Platypus apicalis*, *P. gracilis*, *Prionoplus reticularis*, *Amylostereum areolatum*, and *Sirex noctilio*.

The detailed analysis of each organism was designed to determine its potential risk to US forest resources. The assessment was premised on the continued implementation of certain mitigation practices by New Zealand exporters. These included rapid processing of logs from felling to shipping, debarking, fungicide and insecticide treatment, visual inspections, and in-hold fumigation. Seven risk elements were used in the assessment and then combined into a final Pest Risk Potential. The seven elements were probability of occurrence with host, probability of transport, probability of establishment, potential for spread in the US, economic damage potential, environmental damage potential, and perceived damage.

Of the seven pests analyzed, the *S. noctilio/Amylostereum areolatum* complex poses a moderate to high risk, and *P. reticularis* and *L. truncatum* a moderate risk from log importation. Because these organisms can be found deep in the wood, it is unknown whether the proposed New Zealand industry mitigation procedures would completely eliminate the risk of transport.

The following recommendations were made if log importation does occur:

1. Current mitigation procedures followed by New Zealand exporters should be continued;

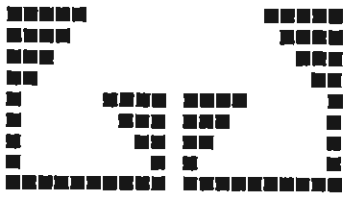
2. Fumigation should be conducted aboard ship at dock side in New Zealand;

3. All holds or containers containing fumigated logs should be sealed by Ministry of Forestry approved personnel and remain sealed until verification by APHIS inspectors upon arrival in the US;

4. Imported logs should be segregated from domestic timber/lumber until processed;

5. Imported logs should be processed immediately; and

6. Logs from several of the first shipments, and periodically thereafter, should be monitored at mill sites by appropriate personnel to determine if any viable quarantine pests are present.



REGULATORY ISSUES WITH IMPORTING FOREIGN LOGS TO NORTH AMERICA

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The Animal and Plant Health Inspection Service (APHIS) is the regulatory branch of the United States Department of Agriculture (USDA) charged with protecting American agriculture from foreign plant pests, new to or not widely distributed within the United States, and to facilitate agricultural exports by certifying to the phytosanitary condition of agricultural products relative to the regulations of the importing country. Before the 20th Century, transportation was slow and commodities and people moved in small numbers. Unfortunately, even under those circumstances, many agricultural pests moved to the U.S. with nursery stock, domestic animals and other agricultural products. By the beginning of this century so many new pests were evident that Congress passed the Plant Quarantine Act of 1912 which authorizes the Secretary of Agriculture to regulate the importation of nursery stock and other agricultural products by prohibition, issuance of plant importation permits, and inspection of commodities in commerce including destruction of infested products.

Specific regulation of timber and forest products was not necessary until very recently. We have traditionally been an exporter of logs and lumber. Recent lessening of the quantity of logs available, particularly from public land, due to environmental concerns for old forests and endangered species and the closing of a number of sawmills in the Pacific Northwest created interest in importing logs from foreign sources. These requests highlighted the deficiency in our regulations regarding forest products. To legally prescribe conditions for entry of a commodity, a specific quarantine must be published under the authority of the Plant Quarantine Act. Such quarantines are in place for many commodities including nursery stock and fruits and vegetables. The entry conditions can include such requirements as fumigation, freedom from soil, freedom from leaves, and size and age requirements. Since logs and lumber have not been imported in appreciable quantities no such quarantine is in place. This does not mean that APHIS cannot take action on their importation, but it does limit actions available to specific action on a particular shipment after it arrives in the U.S. Another legislative Act, the Federal Plant Pest Act of 1957 provides USDA with authority to take quarantine on any commodity entering the U.S. which is found to be infested with quarantine pests.

This situation is not acceptable for large shipments of logs and unmanufactured forest products. The importer must know what conditions are required to efficiently and economically import a commodity and APHIS must be able to take action including preventive action to effectively exclude known pests. About two years ago, in early 1990, we received the first requests to import logs from Siberia. Industry indicated a desire to import a few containers of softwood logs to test import procedures and the market qualities of Siberian larch and pine. These shipments indicated potential problems with insects, particularly bark beetles, and nematodes and plant diseases. Although no actionable federal plant pests were found, inspection indicated nematode and disease pests for which the state of California required quarantine action. The shipments were fumigated and the resulting lumber was kiln dried. Other products, such as bark and sawdust, were burned.

Because of the clear indication of potential pest problems, USDA issued a ban on the importation of logs from Siberia in September 1990. This ban is still in effect. To better regulate the entry of these products, APHIS also indicated its intentions to promulgate a quarantine on forest products. The first step in the process, gathering specific information on pest conditions, was taken by searching the literature for pest reports and by sending a joint Forest Service-APHIS group to Siberia to study conditions on site. This group visited the production areas in Siberia and the Soviet Far East including sawmill and port facilities there. Their report indicated potential pest problems in three areas on logs: hitchhikers and surface pests on the bark and exterior of the logs, pests under the bark, and deep wood pests, particularly plant diseases, in the wood to the center of the log. An accompanying report discussed the mitigation measures

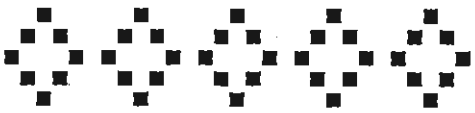
available for the pests identified. This report indicated some data are available on fumigation of surface pests, particularly insects, but that no conclusive data are available, except for heat treatments, on treatment effectiveness for plant diseases in the center of the log.

These reports clarified to both industry and regulators the problems involved in importing large quantities of logs. These include the inability to effectively inspect the product, lack of data on specific treatments, the possibility of the escape of flying insects before treatment, and the operational difficulties involved in both fumigation and heat treatment of large quantities of logs on arrival in the U.S. Industry's interest in importing logs and their desire to cooperate with government in regulating the entry of logs continues. An attempt was made to develop a protocol for the safe entry of larger scale test shipments of Siberian larch. The resulting protocol was so stringent and expensive that industry considered it impractical.

APHIS is developing specific regulations on forest products. Publication of a quarantine is a lengthy process. An advance notice of proposed rulemaking will be published in late summer. This notice will request information on log and unmanufactured wood product importation from interested parties. This information will be used to supplement other available information in developing a proposed rule. This proposal could be published in early 1993. A public comment period will be included in the proposal allowing specific comments on the proposal. Any comments received must be considered and answered in a final rule, which could be published and effective in early 1994.

What is industry and APHIS doing in the meantime? In addition to Siberia, inquiries have been received for importation of *Pinus radiata* and Douglas-fir logs from New Zealand and Chile. These trees are plantation grown and may pose different quarantine risks than the Siberian logs. A joint Forest Service-APHIS study group is being formed to study the conditions in New Zealand. Their reports will be used to assist APHIS in making decisions on the entry status and conditions for importation from that country. As additional requests are received, biological assessments will be made on specific pest conditions in the country of origin before importation decisions are made. Industry continues to cooperate in the development of procedures for this commercial and quarantine activity. Although no regulations exist, only a few small shipments of logs have been made.

In closing, I would like to state that most countries have specific regulations on importing wood products. The European Economic Community has recently strengthened their requirements concerning debarking and fumigation or kiln drying of most wood products, including prohibition of some products. USDA intends to enact regulations to effectively protect American forests and agriculture from foreign pests with the least interference with commerce.



DO HEALTHY TREES MAKE A HEALTHY ECOSYSTEM?

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Introduction

Forest health, depending on how it is described, can be viewed in different ways. Tree pathogens and insect pests have been widely viewed in the past as having primarily negative impacts, even when the damage they cause is not widespread. We have observed that many of these interacting agents and the effects on their tree hosts enhance wildlife habitat and diversity in natural and managed ecosystems. Their beneficial values should be considered when making forest management decisions. These include the alteration of habitat to increase the diversity and quantity of food and shelter essential to many plants and animals as illustrated by the following examples.

Decayed Trees are Important to Cavity Nesters

Nesting cavities are formed in old-growth aspen affected by heartrot and canker fungi. For example, out of 41 tree cavities used by boreal owls on the Superior National Forest in Minnesota, 38 were found in old growth aspen. Aspen rotations of 40 years may be too short for cavity-dependent species such as woodpeckers and owls.

Cankers Benefit Woodpeckers

Larvae of wood borers associated with cankers on aspen are a valuable food source for woodpeckers.

Fallen Trees are Useful to Many Forms of Life

Fallen trees provide seedbeds and nutrients for seedlings. These logs are used by squirrels to store food and also provide food, shelter, moisture, and breeding sites for fish, amphibians, and reptiles. In fact, at least 30% of the birds, mammals, reptiles, and amphibians of this Nation's forests depend on snags and fallen trees to meet their life needs.

Dwarf Mistletoes Increase Species Diversity

Dwarf mistletoes contribute to species richness by creating openings in canopies that provide a diverse habitat attractive to many species. Mistletoe brooms provide nesting sites. Insects associated with declining trees are sources of food.

Diseased Elm Trees are Used by Woodpeckers

Pileated woodpeckers actively seek out dead trees to forage for insects. For example, 27 out of 32 elm trees infested with wood borers and observed over a 6 year period were extensively used.

Insect Pests are Food for Many Animals

A pair of breeding warblers search up to a million leaves to find and remove about 1,000 caterpillars in a 10-day period. Black bears eat ants found in dead wood and can eat up to 25,000 forest tent caterpillars per day.

Summary

* Forest health is a complex issue and it means different things to different people.

* Insect pests and diseases can contribute to forest stability, productivity, and species diversity.

* Dead and dying trees provide benefits critical to the survival of many forest animals.

* Ecosystem management requires us to understand how all parts of the forest community interact so we can maximize biodiversity and enhance multiple values.

Acknowledgements

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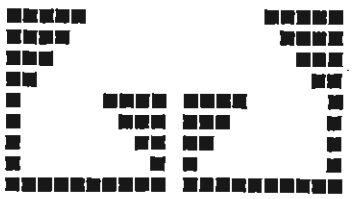

POTENTIAL USES OF A FOREST CANOPY ACCESS FACILITY FOR FOREST DISEASE RESEARCH

David C. Shaw

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The Olympic Natural Resources Center is in the process of establishing a forest canopy research facility in western Washington State. The facility will consist of a long term forest ecosystem research site with a construction crane as the centerpiece. The crane will stand with the arm (jib) above the tallest trees and a gondola will be hung at the hook to transport researchers to any given location above the forest floor and within the reach of the crane arm. A 80 meter crane arm would give the facility access to almost two hectares of forest.

This facility will be very useful for studying forest pathology because an entire forest stand, in three dimensions, will be accessible to researchers. The hard to access growing tips of branches, terminal buds, small branches, and upper tree boles can be accessed with this system. Heavy equipment can be transported to these difficult to access locations, and can be done so repeatedly. Process oriented research, like the dynamics of diseases and host-parasite interactions, can be accomplished due to the repeatability of access. A short list of research potential includes; dynamics of dwarf mistletoes, biology and ecology of rusts, foliage diseases, cankers, and bark and stem diseases, process and development of wood decays in live trees and snags, root disease relationship to overall tree physiology and health, mycorrhizae and tree health, processes of mortality, and manipulative experiments, especially with non-infectious disease agents.

DISEASE INDUCED ASPEN REGENERATION FAILURE IN COLORADO

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Introduction

Throughout Colorado, disease induced regeneration failure occurs in aspen stands within 3-8 years following cutting. Part or all of a stand is affected in an estimated 10% of the stands. Two canker fungi (*Cytospora chrysosperma*, *Dothiora polyspora*) cause death of the aspen sprouts. Both fungi are damaging on stressed trees. The project seeks to identify interacting site and environmental conditions that predispose aspen sprouts to these pathogens. The specific research objectives are to determine if: the incidence of canker diseases is related to soil water changes; site factors aggravate soil water changes, and the occurrence of canker diseases is related to weather conditions.

Materials and Methods

Seven study sites throughout Colorado are being utilized. Each site consists of a pair of plots. A plot with 95% sprout mortality is paired with a plot within the stand or within 2 miles where at least 50% of the sprouts are alive. Data are being collected on sprout number, size and health, previous stand make up, stand slope, aspect, and habitat. Soil pits are used to describe soil morphology, density, texture/particle size, structure and nutrient content. Neutron probes are used to determine soil moisture throughout the growing season to a depth of 1.8 m. Nine access tubes are used in each plot. Weather data from stations near the research sites will be analyzed to determine if particular conditions predispose aspen sprouts to canker pathogens. On-site-weather stations at two study sites will be used to relate nearby weather station data with stand conditions.

Results

Specific results are unavailable to date. This summer, collection of the second year of soil moisture data and description of soil systems on half of the sites is occurring. Our current hypothesis, based on site observations is that the site (soil and soil water conditions) restricts root development. Thus, during late season droughts the trees become predisposed to canker pathogens. This year we hope to determine the site and environmental conditions that are responsible for restricting root growth.

IMPORTANCE OF HEARTROT FUNGI IN LIVING ASPEN IN CREATING POTENTIAL NESTING SITES FOR PICIDS

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To determine the number of cavity-containing stems in old-growth (>80 years) aspen (*Populus tremuloides*), we counted the number of aspen stems which contained cavities in 132 0.02-ha plots in Wyoming. There were 8.7 stems with cavities/ha of aspen type. At least 84% of the stems were alive when the initial cavity was constructed; 59% were alive when examined. *Phellinus tremulae* (a heartrot fungus) fruiting bodies were present on 70% of all cavity-bearing stems but on only 9.6% of all stems >15 cm DBH. Cavities were present in 7.7% and 0.2% of living stems with and without fruiting bodies, respectively. Average DBH of cavity-bearing stems was 27.4 cm. During a 4-year interval 28% of 775, 32% of 217 and 44% of 9 aspen snags 2.5-15 cm, 15-30 cm and >30 cm DBH, respectively, fell. These data indicate that some primary cavity-nesting birds preferentially selected as nest sites living aspen stems with heartrot.

SOLAR HEATING OF SOIL AMENDED WITH CABBAGE CONTROLS *MACROPHOMINA PHASEOLINA*

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Introduction

Charcoal rot caused by *Macrophomina phaseolina* can be a serious disease in forest tree nurseries in the southern United States including the warmer regions of California (2). The severity of charcoal rot of conifer seedlings is directly related to the inoculum density of the fungus in nursery soil (5). The disease currently is controlled in nurseries by soil fumigation with methyl bromide + chloropicrin (10). Both fumigants are under review by the EPA. The latest concern involves the depletion of stratospheric ozone by methyl bromide. Even if both fumigants remain available, alternative methods of control without pesticides is a desirable goal for economic and environmental reasons.

Solar heating of soil under clear polyethylene tarps has effectively controlled many soil-borne plant pathogens including plant pathogens in forest tree nurseries (1). However solar heating of bare soil for control of *M. phaseolina* has not been effective in California (6) and Arizona (8).

It has been demonstrated that cabbage yellows, caused by *Fusarium oxysporum* f. sp. *conglutinans*, can be controlled by solar heating of soil amended with cabbage (9). The addition of cabbage enhances the process as a result of volatile compounds released by the decomposing cabbage. The use of a tarp is essential to trap fungitoxic gases (4). We decided to determine if solar heating of soil amended with cabbage would provide control of *M. phaseolina*.

Materials and Methods

The experiment was conducted at the Institute of Forest Genetics (Pacific Southwest Forest and Range Experiment Station, USDA), Placerville, CA. The soil (Aiken clay loam) was naturally and uniformly infested by *M. phaseolina*. There was an average of 12.3 sclerotia/g of soil prior to initiation of solarization. Cabbage ('Grenedere') grown in the Salinas Valley was chopped, dried in the sun, and incorporated at 1793 g/m² (8 tons/A). Alfalfa meal, a non-cruciferous crop was also incorporated in separate plots at the same rate. The soil and amendments were mixed thoroughly to a depth of 15 cm. The plots were then irrigated and covered with clear polyethylene, 2 mil thickness. Tarps were installed on 6/18/91 and removed on 8/1/91. The trial included solarized amended and unamended plots. Each treatment was replicated 4 times in a randomized complete block design. All plots were 1 m². Following solarization the soil was assayed for the *M. phaseolina* (7) and *Fusarium oxysporum* (3). Data was analyzed and subjected to the Duncan-Waller K-ratio (LSD) test.

Results and Discussion

The results are presented in the following graphs. It is of interest to note that alfalfa meal also enhanced the control by solarization. This suggests that in addition to volatile compounds, other biological activities are contributing to the killing of *M. phaseolina*. It is also noteworthy that control of *Fusarium oxysporum* was not as good in the alfalfa amended solarized soil as in bare solarized soil. This possibly is due to colonization of the alfalfa meal by *F. oxysporum* after incorporation and before the soil temperatures reached killing levels. The alfalfa meal prior to incorporation was free of *F. oxysporum*.

The plots were sown with *Abies concolor*, *Pseudotsuga menziesii*, and *Pinus lambertiana* in May, 1992. We plan to test other crucifers species grown in place, and lower rates of cabbage incorporation.

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OCCURRENCE OF PHYTOPHTHORA LATERALIS ON PACIFIC YEW

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Gregg DeNitto
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Port-Orford-cedar (POC), which naturally occurs only in SW Oregon and NW California, was until recently the only known host for *Phytophthora lateralis*, causal agent of POC root disease. During the 1980s, declining Pacific yew with phloem necrosis were observed on the Gasquet Ranger District in northern California; in June 1990, *P. lateralis* was isolated from "stained" phloem collected from the root collar of a dying Pacific yew (DeNitto and Kliejunas 1991). This discovery indicates that the potential range of the pathogen is greater than previously thought, as the geographic range of yew is greater than POC. Pacific yew is an understory component of most POC communities, thus the discovery of yew as a host for *P. lateralis* has implications for management of POC root disease.

The cultural characteristics of isolates from Pacific yew match the descriptions of *P. lateralis* isolated from POC (P. Hamm and E. Hansen, pers. comm.; Tucker and Milbrath 1942; Trione 1974). Koch's postulates were fulfilled in an inoculation experiment to confirm Pacific yew as a host. A high proportion of rooted yew cuttings inoculated with *P. lateralis* developed symptoms, and the fungus was recovered from diseased tissue. POC seedlings were more susceptible to the fungus than yew cuttings.

In 1991, a streamside survey of selected drainages in NW California and SW Oregon was conducted. The location of declining yew was mapped, and information was collected on tree symptoms, site characteristics, and proximity to infected POC. Isolations were made from approximately 40 symptomatic yew trees; 16 of these were confirmed as infected by *P. lateralis*. The location of these 16 trees is widely dispersed over the range of the disease in POC. The typical habitat in which infected Pacific yew were found was flat swales where the ground could be saturated for long periods of time or along the water's edge in slow-moving water. No diseased yew were found in the absence of infected POC, and most of the infected yew had a diseased POC within 10 feet. The first crown symptom was generally a loss of the older needles, followed by a yellowing of the remaining needles. Infected trees demonstrated flame-shaped areas of cinnamon-brown stained phloem extending up the base of the tree.

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THE HUMONGOUS FUNGUS...AND NOW THE REST OF THE STORY

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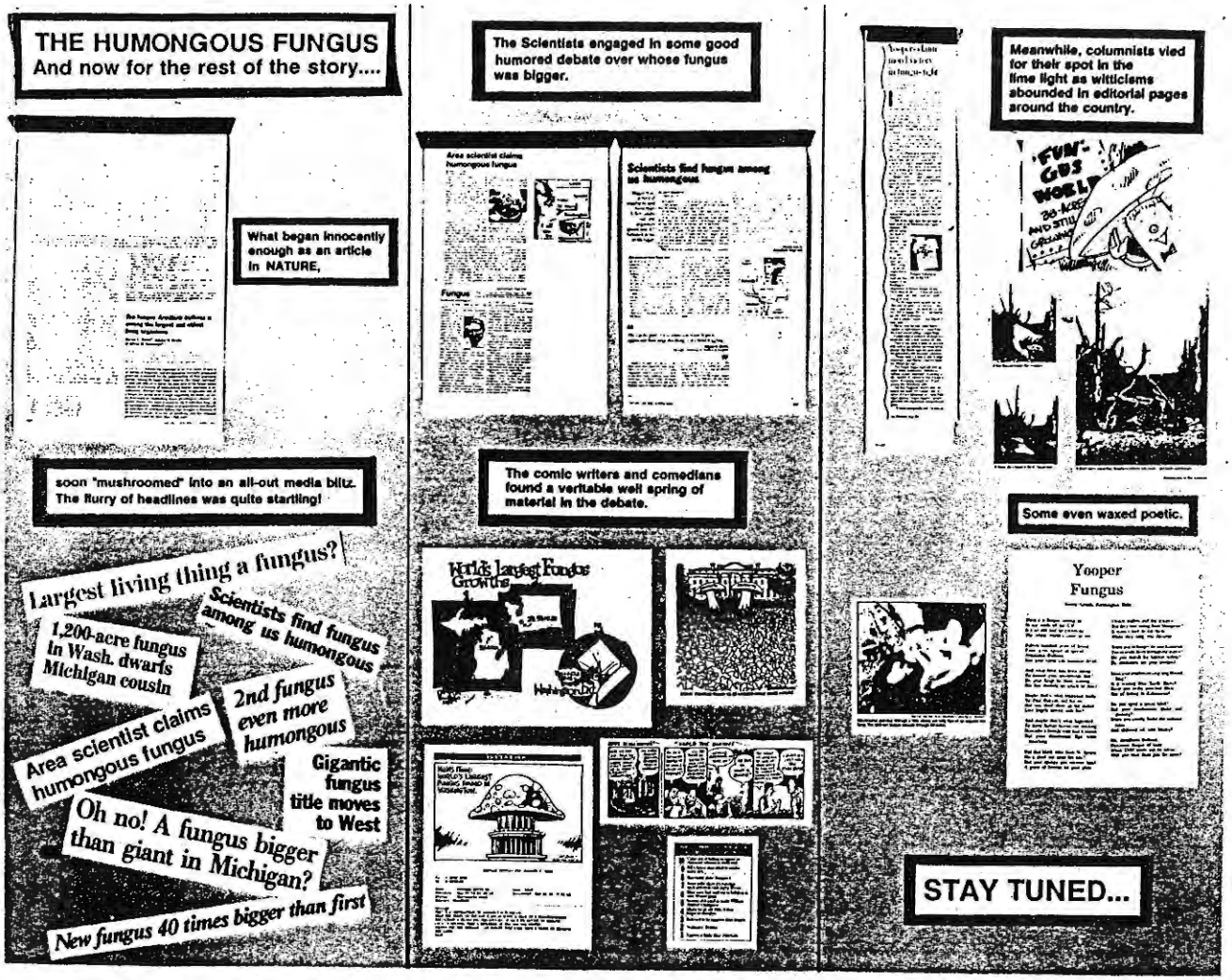


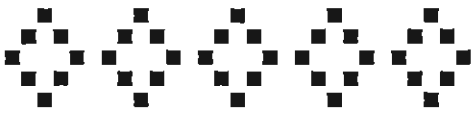
THE RELATIONSHIP OF PINYON PINE MORTALITY TO TREE DIAMETER AND SUBSTRATE ON ANIMAS CITY MOUNTAIN, DURANGO, COLORADO

Results of a class project conducted by students in Biogeography,
Bio 476, Department of Biology, Fort Lewis College, Durango, CO

Participants: Douglas Bradley, Shannon Landreth, Cindy Persichetty,
Jim Siscoe, Trudy Webster, A.W. Spencer

Abstract

In Spring, 1991 we studied the distribution of live and dead pinyon pines within the site of a striking dieoff that had peaked in 1984 on Animas City Mountain, north of Durango, Colorado. We measured trees' stem diameter, categorized condition and positions within four 60-meter-wide transects extending 200 to 400 meters upslope. Trees of 7 - 25 cm basal diameter suffered higher mortality or more severe damage than either larger or smaller trees. The size-condition relationship for trees >30 cm diameter is confounded with substrate since virtually all pinyons of this size, on our transects, occurred on the Morrison stratum. The highest mortality rates occurred within the portion of the slope where the underlying rock strata are the Entrada Sandstone (lower bed) and the Junction Creek Sandstone (upper bed). Mortality was significantly lower on slopes underlain by Morrison sediments. The narrow vertical extent and general stratigraphic conformation of the outbreak are consistent with the assumption that substrate conditions have influenced the vulnerability of pinyons to physical and/or biotic stresses.



WIFDWC DWARF MISTLETOE COMMITTEE REPORT, 1991-1992

Frank G. Hawksworth and John A. Muir

I. TAXONOMY, HOSTS AND DISTRIBUTION

a. We expect to finish the manuscript for our revision of the dwarf mistletoe monograph in 1992. The new monograph will treat 47 taxa compared to 32 in the 1972 version. Most of the recently discovered species are in China, Mexico, and the western United States. The coverage will expand over that of the original version, which concentrated on biology and taxonomy, and will consider ecology, biotic associates (insects, birds, mammals, fungi), effects on hosts, and control. (F. G. Hawksworth, RM Station, and D. Wiens, Univ. of Utah).

b. The publication of the separation of the hemlock dwarf mistletoe, *Arceuthobium tsugense* into 3 taxa is finally in press in the new journal "Novon." As now understood, subspecies *tsugense* comprises two host races, one on western hemlock from Alaska to NW California and one on shore pine in south coastal British Columbia and Orcas Island, Washington. Subspecies *mertensianae* occurs mainly on mountain hemlock from central California at least as far north as Cypress Bowl just north of Vancouver, BC. The same publication includes formal descriptions of three new species: *A. monticola* on western white pine, *A. siskiyouense* on knobcone pine, and *A. littorum* on Monterey and bishop pines. (F. G. Hawksworth, RM Station; D. Wiens, Univ. of Utah; D. Nickrent, Sou. Ill. Univ.).

II. PHISIOLOGY AND ANATOMY.

a. A study was made of the shoot system anatomy of 10 species of *Arceuthobium* from Mexico and the United States. Several salient features of the genus are evident. These plants are characterized by glabrous shoots with squamate leaves and stems displaying an anomalous pattern of primary and secondary growth. Stomata have a transverse orientation in both stems and leaves, and are most abundant on abaxial leaf surfaces. Stems have a distinct vascular cylinder with collateral vascular bundles containing both phloem and xylem. Conducting elements of the xylem are vessel members with simple perforations. Graniferous tracheary elements were observed in stems, leaves, and fruits. Sieve-tube members with generally simple sieve plates occur in the phloem. Stems of woody species may exceed 4 cm in diameter and contain abundant secondary vasculature. Reduced members have only primary vasculature and sieve tube members may be sparse or absent in the phloem. The epidermis of species with long-lived shoots is gradually replaced by a cuticular epithelium. Our work has shown that the widely held belief that *Arceuthobium* lacks both a central vascular cylinder and leaves is incorrect. (C. A. Wilson and C. L. Calvin, Portland State Univ. - Amer. J. Botany 78 (6), Suppl. p. 37, 1991).

III. LIFE CYCLES

a. Preliminary studies were made in Southeast Alaska to try to explain why the infection rates of *Arceuthobium tsugense* in young western hemlock are much less there than in southern British Columbia, Washington, and Oregon. The first surprise was the discovery that in Alaska female plants out number male plants by a fairly consistent ratio of almost 2:1 (based on 11 populations). However,a small sample (3 populations) in northern Washington showed a similar ratio. The sex ratio is approximately 1:1 in most other dwarf mistletoes that have been studied. The fruit/flower ratio (proportion of flowers that form a mature fruit) for Alaska (54%) was significantly lower than in Washington (67%). The relationship of these differences to infection rates are as yet unclear. Further studies are planned for Oregon and Washington this fall. (D. Wiens, Univ. of Utah; C. Shaw and F. G. Hawksworth, RM Station; and P. Hennon, FPM, R-10).

b. About a dozen young Douglas-firs (ca. 3-4 m tall) were inoculated with *Arceuthobium douglasii* seeds in northern Arizona in 1954. A cursory examination of the trees in 1991 showed a high rate of intensification in some trees (from DMR Class 1 or 2 to 6). A more detailed examination and analysis of the results is planned. (F. G. Hawksworth, RM Station).

IV. HOST-PARASITE RELATIONS

a. A study of Douglas-firs infected by *Arceuthobium douglasli* and uninfected trees was conducted in southern New Mexico to compare phenology and biomass as they relate to infestations by the western spruce budworm. More buds were present on non-infected trees than on broomed or non-broomed branches of infected trees. Infected branches showed a slightly accelerated bud initiation than other branch types, although both infected and uninfected branches completed bud break within the same period. On infected trees, shoot elongation from brooms was greater than non-infected shoot growth an all parts of the crown. (J. W. Briede and J. G. Mexal, New Mexico State Univ., and A. M. Lynch and F. G. Hawksworth, RM Station).

b. A study was initiated in 1991 to determine the approximate ages and heights at which young western larch are first infested by larch dwarf mistletoe in northern Idaho. One hundred infected larch saplings growing near heavily infected overstory trees were examined. Their age and height when initially infected was determined by aging all mistletoe infections on each sapling. Initial infection age was calculated by subtracting the age of the oldest mistletoe infection from the total age of the sapling. Initial infection height was determined by counting down from the top of the sapling the number of whorls equal to the age of the oldest mistletoe infection and measuring the height to that whorl. One year was not added to infection ages to allow for a "lag" period before annual ring distortion appears in stem cross sections as with other dwarf mistletoes. If anyone has specific data on a "lag" period for aging larch mistletoe infections, please contact me.

One sapling was infected when it was only three years old, but five feet in height. Most of the saplings (83 percent) were taller than breast height before they were infected. Ninety-two percent of the one hundred saplings were infected after they were seven years old. Seventy-nine percent of these saplings were seven, eight, or nine years old when first infected. Additional infected larch saplings will be examined in the fall of 1992.

The study will be expanded in 1992 to include establishment of several permanent plots around mistletoe-infected larch seed trees. Infection of larch regeneration in the plots will be monitored for several years. (Bob Mathiasen, Idaho Department of Lands, Coeur d'Alene, Idaho)

V. EFFECTS ON HOSTS

a. The distribution of dwarf mistletoe (*Arceuthobium americanum*) and its effects on basal area growth were studied in more than 4,000 trees in three 5-acre plots in 300-year old-growth lodgepole pine (*Pinus contorta* subsp. *latifolia*) stands on the Fraser Experimental Forest, Colorado. From 34 to 60 percent of the plot areas were infested, but no isolated infected centers were found. This is in marked contrast to nearby 70-year old stands that had an average of 1.4 isolated infection centers per ha. Basal area growth was significantly reduced only in the most heavily-infected trees (Dwarf Mistletoe Rating Class 6), and here the reduction was less than 30%. This is much less effect than is found for the same mistletoe in younger stands: Class 4 (6% reduction), Class 5 (20% reduction), and Class 6 (42% reduction). These results suggest that old-growth trees somehow tolerate dwarf mistletoe infection more than younger trees do. (F. G. Hawksworth, W. H. Moir, and J. E. Janssen, RM Station).

b. Since 1950, we periodically recorded information on the diameter, longevity, and dwarf mistletoe (*Arceuthobium vaginatum*) rating (6-class DMR system) of 1,957 ponderosa pine trees on 9 fixed area plots covering 48 acres in Grand Canyon National Park (AZ) and Mescalero Indian Reservation (NM). Survival analysis with censored data and covariates for initial diameter and DMR generated a Weibull probability function for the longevity of ponderosa pine trees within mistletoe infested stands. This model can be used to estimate mortality rates over variable periods (5 to 25 years), does a good job of smoothing "pulses" of mortality, and provides confidence limits on estimates. Mortality rates decline in direct proportion to tree diameter and increase exponentially with DMR. More than 50% of Class 6 trees <15 in. dbh are projected to die within 20 years; but more than 70% of Class 6 trees >30 in. dbh are expected to survive at least 20 years. (B. W. Geils, F. G. Hawksworth, and J. E. Janssen, RM Station).

VI. ECOLOGY

a. The dwarf mistletoe *Arceuthobium americanum* has an upper elevational limit about 500 feet below the upper limits of its host, lodgepole pine, in the central and northern Rocky Mountains. To help explain this limit, a study was begun in 1968 by transplanting infected pines into the mistletoe-free zone in northern Colorado. The study has been monitored for more than 20 years, and although mistletoe fruits were formed each year on the transplanted trees, they did not mature. This suggest that the upper limit of the parasite is governed by the length of the growing season. At higher elevations the fruits apparently do not have enough time to fully develop so freezes in the fall prevent seed dispersal. (F. G. Hawksworth, RM Station and J. G. Laut, Colo. State For. Serv.).

b. A study was made in central Colorado to determine the indirect effects caused by dwarf mistletoe (*Arceuthoblum vaginatum*) in ponderosa pine forests (stand opening, tree mortality, witches' brooms) on bird populations. Four study areas (1 in a lightly-, 2 in moderately-, and 1 in heavily infected stands) were established in two areas. Numbers of snags and the number of cavity-nesting birds using them were positively correlated with the level of mistletoe infection. The number of bird species and total numbers of birds were also positively correlated with level of mistletoe. (R. Bennetts and G. C. White, Colo. State Univ. and F. G. Hawksworth, RM Station).

VII. CONTROL - CHEMICAL

a. A test of Ethephon on *Arceuthobium globosum* on *Pinus hartwegii* was made near Mexico City. Nineteen trees were sprayed: 10 at 2200 ppm (6 with a sticker and 4 without) and 9 at 2700 ppm (5 with a sticker and 4 without). Prior to spraying each tree was given a 6-class rating based on mistletoe plants (this species has shoots that are frequently over 1 foot high!). Some shoot abscission was apparent after 2 weeks but it was most pronounced after 4 weeks. There was no difference between the two dosages and the addition of a sticker had no effect. Trees rated as 5 or 6 were reduced in rating by 3 classes, and trees rated as 3 or 4 were reduced to essentially zero. No information is given on resprouting. (D. Alvarado R. and J. Cibrian T., Mexico City - The results will be published in the Proceedings of the VI Simposio Nacional sobre Parasitologia Forestal.)

b. In June 1992, tests were begun with microinjections of 3 rates of the DuPont herbicide Velpar to determine its effects on *Arceuthobium americanum* of lodgepole pine at the Fraser Experimental Forest, Colorado, and on *A. vaginatum* of ponderosa pine at the Manitou Experimental Forest, Colorado. (R. Webb, Univ. of Florida; D. Johnson, FPM R-2; and B. W. Geils, RM Station).

c. Evaluation of field tests of the plant growth regulator, ethephon,

has shown that significant abscission of dwarf mistletoe shoots occurs within a few weeks after application. Tests conducted in the Black Forest north of Colorado Springs, Colorado in 1988 on ponderosa pine dwarf mistletoe showed abscission rates of 73 to 98 percent with mid-June, mid-July and mid-August applications of the chemical at rates of 2200 and 2700 ppm ethephon in water with a spreader-sticker.

Examination of trees three years following treatment showed some development of immature shoots on all treatments, but insignificant numbers of mature shoots with fruits on all infections including controls (non-chemically treated trees). The reduction in numbers of infections with shoots observed in the controls is attributed to a combination of natural control agents including, drought, branch mortality, and insects. Observations are planned for several more years to determine when mature shoots will develop on ethephon-treated trees (D. Johnson, USFS FPM R-2).

VIII. CONTROL - BIOLOGICAL

a. Larvae of *Dasypyga alternosquamella* (Pyralidae) were found feeding on lodgepole pine dwarf mistletoe in several locations in the Prince George and Vanderhoof Forest Districts, British Columbia. Many trees had nearly 100 percent of the mistletoe shoots eaten. (R. Reich, BC Ministry of Forests, Pest Management Progress 11(2): 22, 1992).

IX. CONTROL - GENETIC

a. New Mexico State University has initiated studies on dwarf mistletoe resistance in ponderosa pine at the Mora Tree Nursery, near Las Vegas, in northern New Mexico. Root stocks have been established for grafting purposes. Ponderosa pine scions from several sources will be tested in this long-term project. (Dave Conklin, FPM R-3)

b. Bob Scharpf and Lew Roth recently published "Resistance of ponderosa pine to western dwarf mistletoe in central Oregon", USDA Forest Service Research Paper PSW-RP-208, 9 p, 1992. Also another paper is in press: Scharpf, R. F.; Kinloch, B. B.; Jenkinson, J. L., 1992. One seed source of Jeffrey pine shows resistance to dwarf mistletoe, USDA Forest Service Research Paper PSW-PR-207, 8p.

X. CONTROL - SILVICULTURAL

a. Publications summarizing 40-year results for two large-scale *Arceuthobium vaginatum* silvicultural control tests in ponderosa pine in the Southwest are planned for this next winter. The studies are in recreation forests at Grand Canyon National Park in northern Arizona and in timber production forests on the Mescalero Apache Reservation in southern New Mexico. (B. W. Geils and F. G. Hawksworth, RM Station).

b. Catching up on post-treatment evaluations of dwarf mistletoe suppression projects has become a priority. Surveys are conducted at approximately 5 and 10 years after treatment. The data are used to evaluate the success of the project in controlling the intensification and spread of dwarf mistletoe and accomplishing project objectives. Results have been mixed. Most projects are successful but a few have resulted in higher levels of mistletoe following treatment. In one of these the prescription was changed in order to replace volume loss during a timber sale from an area pulled for wildlife protection. (M. L. Fairweather, FPM R-3)

c. Approximately 2,000 acres of National Forest and Indian lands were treated in Forest Pest Management-funded control projects in 1991. Similar acreage is being treated in 1992. (Dave Conklin, FPM R-3)

d. Plans are to treat 1,284 acres of dwarf mistletoe infested stands on the Arapaho and Roosevelt; Grand Mesa, Uncompahgre and Gunnison; Pike and San Isabel; Routt; and White River National Forests (D. Johnson, USFS, R-2).

XI. SURVEYS

a. Presuppression surveys for dwarf mistletoe are planned for 14,711 acres on the Arapaho and Roosevelt; Grand Mesa, Uncompahgre and Gunnison; Pike and San Isabel; Routt; and White River National Forests (D. Johnson, USFS, R-2).

XII. MISCELLANEOUS

a. Permanent plots have been established in forests infected with southwestern dwarf mistletoe and Douglas-fir dwarf mistletoe as part of the "Pest Trend Impact Plots in the West" project. The purpose of the project is to establish and monitor permanent plots in areas affected by specific insects or diseases and use the information to validate the pest subroutines of the Prognosis growth and yield model. These plots range from 0.5-2.5 acres in size and vary in density, vertical structure, dwarf mistletoe infection level, and other site conditions. They were placed in forested stands which would be deferred from activity for at least the next 10 years. This included stands designated for old growth, research, and Goshawk post-fledgling areas. The established plots will be revisited every 2 years. (M. L. Fairweather, FPM R-3)

b. A research project at the Olympic Natural Resources Center will greatly assist in the study of the biology and ecology of western hemlock dwarf mistletoe. We received funding for purchase and siting of a construction crane for canopy access. Currently, we are working to place the crane on the western Olympic Peninsula near Forks, Washington, between a 45-year old Sitka spruce/western hemlock plantation and a mature-old growth riparian stand of western hemlock, Sitka spruce, western red cedar, red alder, pacific yew, pacific silver fir, and one old Douglas-fir. The mature stand has an abundance of booms in the hemlock, and it will be interesting to investigate the plantation for occurrence of mistletoe plants.

I have to admit, however, that we are having some political problems with the project that may require us to move it off the peninsula. This may change the stand type, but my hope is to be sure to get it into a stand with some component of dwarf mistletoe.

The crane we are proposing to purchase should be nearly 65 meters tall (under the jib arm) and have a jib length of approximately 70 to 80 meters. This will give us the capability to access the three dimensional space of a 1.7-2.0 hectare area! This may be as many as 350 or more trees. We can transport researchers and equipment to repeatedly access any given point. We can do in depth studies of physiological effects of mistletoe on western hemlock, pollination, bird use, growth and productivity, shade effects, physiology of mistletoe plants, biomass and nutrient contributions.

We are looking at 1993 for erection for the crane, and research could then begin in fall of 1993. The facility will be open for anyone interested in using it. I expect cost will be based on hourly use. Additionally, the Olympic Natural Resources Center is building a 22,000 square foot research facility in the town of Forks that researchers can use as a base of operations. The facility will have office, lab, and dormitory type accommodations. We won't be moving into that until 1994. Please feel free to give me a call if you want any more information. (D. Shaw, Project Manager, Olympic Canopy Crane, Olympic Natural Resources Center, Forks, Wash. (204) 374-3220)

c. The Interim Dwarf Mistletoe Impact Modeling System is available on the 9 variants of Prognosis Stand Growth and Yield Model using version 6.1. It will be made available on the remaining variants in the near future.

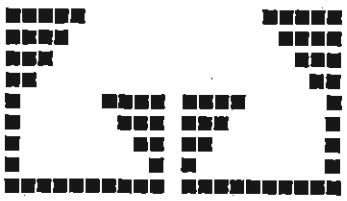
The report entitled "Interim Dwarf Mistletoe Impact Modeling System: Users Guide and Reference Manual" (USDA Forest Service, Forest Pest Management/Methods Application Group, Report No. MAG-91-3, March 1992, 90 pp) has been updated to reflect changes and corrections to the manual and the model. This March 1992 revision replaces the previous October 1991 version.

A mistletoe model design workshop was held March 12-13, 1992, in Portland, OR. Participants included model builders, plant ecologist, plant pathologists, wildlife biologists, statisticians, and systems analysts. Discussions focused on modeling brooms and spiked tops and the interactions among dwarf mistletoe and wildlife, since mistletoe-induced brooms are often used as nesting sites and cover by many species.

Model review workshops were held April 22-24, 1992, in Fort Collins, CO and July 9 in Denver, CO. The model development contractor, Environmental and Social Systems Analysts, Ltd., presented the new mistletoe spread and intensification section of the comprehensive model. Participants reviewed ESSA's design document, "Development of an Integrated Model for Predicting Dwarf

Mistletoe Impacts, February 1992," and discussed model behavior, keywords, possible refinements, data requirements and analysis.

For more information on the Dwarf Mistletoe Model, contact G. Shubert, (303) 498-1733. (B. Eav and G. Shubert, MAG)



ROOT DISEASE COMMITTEE REPORT - 1992

Gregory M. Filip

The root disease committee met and decided to catalogue new and ongoing projects concerning root diseases in western North America. The following are projects that were submitted this year. Additional projects will be included in subsequent committee reports.

PROJECT TITLE: Jack Pine Mortality in the Nebraska National Forest

INVESTIGATOR: Jenny Holah, Pathologist, and Bill Schaupp, Pest Management Specialist, FPM-Region 2, Rapid City Service Center (SD)

COOPERATORS: Mac Deveraux, District Ranger of Bessey Unit, Nebraska National Forest

YEARS: Begun - July 1992; End - Indefinite

PROJECT DESCRIPTION: After a series of overstory cuts in mature jack pine stands in the 1980's, advanced regeneration began a rapid decline at the Bessey unit of the Nebraska National Forest. Mortality in some areas is over 50%. Root systems of young jack pines are heavily pitched, lesions occurred along roots, black-staining occurred within some roots and often extended up the bole, and insect activity was extensive. Mature jack pine and Austrian pines were also affected at the edges of the cuts. A follow-up visit revealed that there is a *Leptographium* sp. present in the roots of affected trees and that *Dendroctonus valens* and a *Hylastes* sp. are possible vectors. Currently we are trying to i.d. the *Leptographium* to species, isolate stain from possible vectors, and determine appropriate control measures.

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PROJECT TITLE: Armillaria Root Disease in the Black Hills National Forest

INVESTIGATOR: Jenny Holah, Pathologist, FPM-Region 2, Rapid City Service Center.

COOPERATORS: Bill Schaupp, Pest Management Specialist, and Judy Pasek, Supervisory Entomologist, FPM-Region 2, Rapid City Service Center

YEARS: Begun - August 1992; End - Indefinite

PROJECT DESCRIPTION: Ponderosa pine stands in the Black Hills are being surveyed for Armillaria root disease in order to answer the questions - what sort of economic impact, if any, does the disease have on timber practices in the Hills, and do various management techniques exacerbate, decrease, or have any effect on disease? The presence of *Armillaria* is known to be widespread throughout the Hills from previous studies, but to date we do not know the dynamics of the disease within stands. There will also be an informal preliminary investigation on the association of *Armillaria* and bark beetle activity within some distance of disease centers.

PROJECT TITLE: Precommercial Thinning in Douglas-fir, Hemlock, True Fir, and Ponderosa Pine Stands Affected by Armillaria Root Disease in Oregon and Washington Cascade Range

INVESTIGATORS: Gregory Filip, Oregon State University and Donald Goheen, Forest Pest Management, Portland

COOPERATORS: Mt. Baker-Snoqualmie, Willamette, Deschutes, and Rogue River NF's; Salem Dist., BLM

YEARS: Begun - 1966, 1979, 1981; End - indefinite

PROJECT DESCRIPTION: Paired, 0.25 acre plots, thinned and unthinned, are examined every 2 years for crop tree mortality by *Armillaria ostoyae*. After 20 years (pine) and 10 years (others), there is no significant difference in crop-tree mortality between thinned and unthinned plots. Diameter growth is significantly greater in some thinned plots.

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PROJECT TITLE: Effects of Harvesting Season and Stump Size on Regeneration Mortality near Grand Fir Stumps Infected by *Heterobasidion annosum* in Northeastern Oregon

INVESTIGATORS: Gregory Filip, Oregon State University; Craig Schmitt, USFS Blue Mt. Zone, La Grande; and Catherine Parks, PNW Station, La Grande

COOPERATORS: Umatilla NF

YEARS: Begun - 1989; End - indefinite

PROJECT DESCRIPTION: 300 stumps on 10 sites were examined for decay caused by *H. annosum* and tallied by season of cutting and stump size. Mortality of regeneration around stumps was recorded. 89% of the stumps were infected. Neither season of harvesting nor stump size affected annosus incidence. Grand fir regeneration mortality was initially low (<1%) and will be monitored indefinitely.

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PROJECT TITLE: Effects of Silvicultural Treatments on Mortality Caused by Root Diseases in High-Elevation Mixed-Conifer Stands in Oregon

INVESTIGATORS: Gregory Filip, Oregon State University; Catherine Parks, PNW Station, La Grande; Helen Maffei, USFS Central Oregon Zone, Bend

COOPERATORS: Wallowa-Whitman, Winema, and Malheur (planned) NF's; Warm Springs Indian Reservation (planned)

YEARS: Begun - 1987, 1990, 1992; End - indefinite

PROJECT DESCRIPTION: Seedtree/shelterwood systems, group-selection systems, commercial thinning, and clearcutting are being tested for effects on residual tree and regeneration mortality caused by *Armillaria ostoyae*, *Heterobasidion annosum*, and other root pathogens. Sites are examined every other year.

PROJECT TITLE: Effect of Fertilizer (N,P,K,S) on Infection Caused by *Armillaria* spp. in Grand Fir Stands in Northeastern Oregon

INVESTIGATORS: Gregory Filip, Oregon State University; Catherine Parks, PNW Station, La Grande

COOPERATORS: Umatilla and Wallowa-Whitman NF's

YEARS: Begun - 1989; End - 1994

PROJECT DESCRIPTION: Four 40-acre blocks were aerially treated with four fertilizer treatments (N, alone; N, P, K, S; 1/3 N, P, K, S; and no fertilizer) each on 10-acre subblocks. 160 mature grand firs (10/subblock) were inoculated with alder stems containing *A. ostoyae*. Another 160 trees were treated with sterile segments. Tree vigor is being assessed using cambial electrical resistance. Some trees have died and are infected by *Armillaria* spp. including trees with sterile segments. Clonal studies are planned to differentiate between artificial and naturally caused infection.

PROJECT TITLE: Distribution, Severity, and Management of Black Stain Root Disease in Ponderosa Pine in Eastern Oregon

INVESTIGATORS: Gregory Filip, Oregon State University; Craig Schmitt, USFS Blue Mt. Zone, La Grande; Catherine Parks, PNW Station, La Grande; others

COOPERATORS: Malheur NF

YEARS: Begun - 1992; End - indefinite

PROJECT DESCRIPTION: Twenty-six 0.1 acre circular plots were established in precommercially thinned and unthinned stands of ponderosa pine to assess mortality caused by *Leptographium wageneri*. All sites are climax ponderosa pine. As funding sources surface, further studies are planned concerning effects of thinning on disease incidence and vector/host relations in these dry ponderosa pine sites.

PROJECT TITLE: Damage by *Poria weirii* to Douglas-fir Stands

INVESTIGATOR: E. E. Nelson, USDA, Forest Service, PNW

COOPERATORS: Various public and private land managers

YEARS: Begun - 1956; End - 2006

PROJECT DESCRIPTION: The objective is to determine rate of damage to Douglas-fir stands of different ages and densities, on different sites, and under different intensities of infection. The study begun by T.W. Childs, involves semi-annual examinations of 10-acre plots to record mortality by cause. Stand basal area is measured at time of plot installation and termination of study. Intermediate reports have been prepared for some plots.

PROJECT TITLE: Resistance of Conifers to *Poria weirii* on Infested Clear-cuts

INVESTIGATOR: E. E. Nelson, USDA, Forest Service, PNW

COOPERATORS: Mapleton District, Siuslaw National Forest

YEARS: Begun - 1971; End - 2004

PROJECT DESCRIPTION: The objective is to determine relative resistance of several conifers to laminated root rot under field conditions. Four plots have been installed. Mortality by cause and growth are measured annually for species of conifers planted on 10 ft. radii around stumps infected with *P. weirii*. A summary to date is being published in W.J.A.F. The paper includes data from a similar B.C. plot, and is being coauthored with Rona Sturrock.

PROJECT TITLE: Effects of Nitrogen Fertilization and Interplanting Alder on Root Disease Development in a Thinned Douglas-fir Plantation

INVESTIGATOR: E. E. Nelson, USDA, Forest Service, PNW

COOPERATOR: Columbia Gorge District, Mount Hood National Forest

YEARS: Begun - 1971; End - 1993

PROJECT DESCRIPTION: The objective is to determine the effects of nitrogen and interplanted alder on stand and root disease development over a 20-year period. Mortality by cause is determined semi-annually. Basal area cruises are made at the initiation and volumes determined at the conclusion of the study. Fertilizer is applied at five-year intervals to four of twelve 1.6-acre plots. Alder planted on four plots did not survive, but data are taken to provide a second set of controls.

PROJECT TITLE: Red Alder as a Control for *Poria weirii* Root Rot of Douglas-fir

INVESTIGATORS: E. M. Hansen, Oregon State University; E. E. Nelson, USDA, Forest Service, PNW

COOPERATORS: PNW Research Station, Oregon State University, International Paper Co., Crown Zellerbach Corp.

YEARS: Begun - 1974; End - 2054

PROJECT DESCRIPTION: The objective is to determine the effectiveness of crop rotations of alder or cottonwood on reducing damage from laminated root rot. The study is on a 35-acre tract of I.P. Co.'s Erickson Tract near Apiary, Oregon. Data are taken semi-annually on Douglas-fir plots to record mortality by cause. First rotation of alder and cottonwood were harvested in 1986. Final rotation of alder and cottonwood will be harvested about 1998. After that time, all 35 acres will be in three generations of Douglas-fir.

PROJECT TITLE: Red Alder as a Control for Poria Root Rot

INVESTIGATORS: E. M. Hansen, Oregon State University, E. E. Nelson, USDA, Forest Service, PNW

COOPERATORS: PNW Research Station, Oregon State University, Port Blakeley Tree Farms

YEARS: Begun - 1975; End - 2035

PROJECT DESCRIPTION: The objective is to determine the effects of interplanting red alder with Douglas-fir on stand development and mortality from *P. weirii*. Data is taken semi-annually. Mortality is recorded by cause. Unexpected mortality to mountain beaver and problems with balancing alder and conifer growth demand considerable effort in plot maintenance.

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PROJECT TITLE: Characterization of *Trichoderma* spp.: Prelude to Biological Control

INVESTIGATOR: E. E. Nelson, USDA, Forest Service, PNW

COOPERATORS: PSW Research Station; University of Wyoming; Oregon State University; CSIRO, Perth, Western Australia

YEARS: Begun - 1990; End - 1994

PROJECT DESCRIPTION: The objective is to determine relationships among isolates of *Trichoderma* spp. and their potential for biological control of P. weirii. Over 1000 isolates of *Trichoderma* spp. are in storage. Most have been identified, and at least two will be presented as new species. Only a small percentage have thus far been tested for antagonism to *P. weirii* by measuring rate of displacement of *P. weirii* from colonized stem sections.

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PROJECT TITLE: Interspecific Grafting of Port-Orford-Cedar: Compatibility, Resistance to *Phytophthora lateralis* and Field Performance

INVESTIGATORS: M. G. McWilliams, USDA, Forest Service, PNW; E. E. Nelson, USDA, Forest Service, PNW; and E. M. Hansen, Oregon State University

COOPERATORS: PNW Research Station, Oregon State University, Port-Orford-Cedar Committee, Siskiyou National Forest, Rogue River National Forest

YEARS: Begun - 1991; End - 2005

PROJECT DESCRIPTION: The primary objectives are to determine if grafts of P-O-C scions to rootstocks of atlantic white-cedar and native western "cedars" will be compatible over time, and if these grafted seedlings are resistant to *P. lateralis*. Resistance will be tested by inoculations under greenhouse conditions and by outplanting on known infested sites. Growth will be monitored and compared to that of nongrafted seedlings.

PROJECT TITLE: Development of an Annosus Root Disease/Bark Beetle Model for Use in Forest Planning

INVESTIGATORS: John Kliejunas, Forest Pest Management, Pacific Southwest Region, San Francisco, CA; Bov Eav, Methods Applications Group, Fort Collins, CO

COOPERATORS: Susan Frankel, Forest Pest Management, Pacific Southwest Region, San Francisco, CA; Gregory Shubert and Matthew Thompson, Methods Applications Group, Fort Collins, CO; Peter McNamee, ESSA, Vancouver, B.C.

PROJECT DESCRIPTION: The Annosus Root Disease/Bark Beetle Model is available for use with the SORNEC (Southeast Oregon Northeast California) variant of the Prognosis Stand Growth and Yield Model. On June 23-25, 1992 in Alturas, CA a hands-on workshop was held where model data collection methods were demonstrated and refined and model behavior was analyzed with runs using inventory and root disease data collected from stands in California and Oregon. Future needs, including model refinements, analysis of model behavior and invalidation with real data were identified as the remaining steps needed for model completion. The model was also presented at this WIFDWC meeting please see the article in this Proceedings "Demonstration of the Annosus Root Disease/Bark Beetle Model" by Susan Frankel, Bov Eav and Greg Shubert.

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PROJECT TITLE: Skimikin Control Trial

INVESTIGATOR: Duncan Morrison, Forestry Canada, Victoria

COOPERATORS: None

YEARS: Begun - 1969; End - indeterminate

PROJECT DESCRIPTION: Combined stumping experiment and species trial consisting of 32 20m plots replicated on a treated and an untreated block. Plots were planted to single species or alternating rows of two species. Twenty-year results are contained in Morrison, D.J., *et al.* 1988. Pacific Forestry Center, Information Report BC-X-302. The plots were reassessed in 1992.

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PROJECT TITLE: Sugar Lake/Nakusp *Armillaria* Spread Plots

INVESTIGATOR: Duncan Morrison, Forestry Canada, Victoria

COOPERATORS: None

YEARS: Begun - 1984; End - indeterminate

PROJECT DESCRIPTION: In Douglas-fir plantations at Sugar Lake (P'67) and Nakusp (P'72), *Armillaria ostoyae* disease centers on a two hectare block were mapped. Trees that died before 1984 were aged and assigned a year of death. The condition of each tree in the blocks is checked biennially.

PROJECT TITLE: Effects of Precommercial Thinning on Crop Tree Infection and Mortality by Root Diseases

INVESTIGATOR: Duncan Morrison, Forestry Canada, Victoria; Don Norris, Hadrian Merler, Jeff Fournier, Don Doidge, Richard Reich, British Columbia Ministry of Forests

COOPERATORS: None

YEARS: Begun - 1991-1992; End - indeterminate

PROJECT DESCRIPTION: In seven spacing-aged stands with disease centers of one of *A. ostoyae* (5), *P. weirii* (1) or *I. tomentosus* (1), ten 0.04 ha plots with 5m-wide buffer were laid out. Five of the ten plots were randomly selected for spacing while the other five were left as controls. The condition of crop trees will be assessed in alternate years.

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PROJECT TITLE: Solar Heating of Soil Amended with Crucifers for the Control of Conifer Seedling Diseases

INVESTIGATOR: A. H. McCain, University of California, Berkeley, CA; R.F. Scharpf, USDA Forest Service, PSWF&RES, Albany, CA; S. J. Frankel, USDA Forest Service, R-5, FPM, San Francisco

COOPERATORS: J. Nelson, USDA Humboldt Nursery

YEARS: Begun - 1991; End - 1994

PROJECT DESCRIPTION: Soil infested with *Macrophomina phaseolina* and other conifer seedling pathogens such as *Fusarium oxysporum*, was amended with various rates of cabbage and solarized. Inoculum densities of *F. oxysporum* and other pathogens are being monitored. In 1991, a high rate of cabbage was effective in controlling *M. phaseolina*, and *F. oxysporum*. Lower rates are now under investigation at the USDA Institute of Forest Genetics, Placerville, CA. The high rate is being evaluated at the USDA Humboldt Nursery in 1992. Various crucifers will be grown, incorporated, and the soil solarized at the Institute. Inoculum densities of the pathogens will be monitored.

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PROJECT TITLE: Susceptibility of Conifer Tree Species to Laminated Root Rot in Northeast Oregon

INVESTIGATOR: Alan Kanaskie, Gene Irwin, Larry Weir, Oregon Forestry Department.

COOPERATORS: None

YEARS: Begun - 1980; End - indefinite

PROJECT DESCRIPTION: A mixed conifer stand, heavily infested with laminated root rot, was mapped and logged in 1978. Stumps were removed on half the area. Douglas-fir, western larch, Englemann spruce, ponderosa pine, and grand fir were planted in 1980. Mortality from root disease is monitored periodically.

PROJECT TITLE: Rate of Expansion of Laminated Root Rot in Centers in Second Growth Douglas-fir Stands in Northwest Oregon

INVESTIGATOR: Alan Kanaskie, Gene Irwin, Oregon Forestry Department

COOPERATORS: None

YEAR TO BEGIN AND END: Ongoing. Disease progression is being tracked on three permanent plots of second growth Douglas-fir in the Coast Range of Oregon.

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PROJECT TITLE: Landscape-level Mapping of Laminated Root Rot in Western Oregon

INVESTIGATOR: Alan Kanaskie, Oregon Forestry Department

COOPERATORS: None

YEARS: Begun - 1989; End - indefinite

PROJECT DESCRIPTION: Laminated root rot and other root diseases are mapped via ground surveys over large areas (500-2,000 acres) in western Oregon. Such mapping reveals the size and distribution of this important disturbance event.

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PROJECT TITLE: Occurrence of Armillaria Root Disease among Families of Coastal Douglas-fir in Provenance Test Sites

INVESTIGATOR: Alan Kanaskie, Oregon Forestry Department

COOPERATORS: Willamette Industries

YEARS: Begun - 1987; End - indefinite

PROJECT DESCRIPTION: Development of Armillaria root disease is being monitored in a progeny test site in coastal Oregon to determine whether or not resistance is related to host tree genotype.

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PROJECT TITLE: Biosystematics of *Armillaria*

INVESTIGATOR: H. Burdsall, Center for Forest Mycology Research, Forest Products Lab., Madison, WI

COOPERATORS: Numerous

YEARS: Begun - 1992; End - 1997

PROJECT DESCRIPTION: To differentiate the species of *Armillaria* and relate their occurrence to function in the ecosystem.

PROJECT TITLE: Biosystematics of *Phellinus*

INVESTIGATOR: M. Larsen, Center for Forest Mycology Research, Forest Products Lab., Madison, WI

COOPERATORS: Numerous

YEARS: Begun - 1992; End - 1997

PROJECT DESCRIPTION: To differentiate the species of *Phellinus* and relate their occurrence to function in the ecosystem.

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PROJECT TITLE: Hazard Rating System for Ponderosa Pine (*Pinus ponderosa* Dougl. ex Laws.), White Fir (*Abies concolor* (Gord. & Gled.) Lindl. ex Hildebr.) and Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco)

COOPERATORS: Sante Fe National Forest (Jemez District), FPM Albuquerque
J. Friedley (BIA)

YEAR TO BEGIN, YEAR TO END: 1991 - 1992

PROJECT DESCRIPTION: The objective of this project is to formulate a hazard rating system for infected trees by characterizing the extent of root disease development in variously sized conifers in comparison to crown condition and other measurements of tree vigor. In the summer of 1991, 36 Douglas-fir, 36 white fir and 10 ponderosa pines were examined on the Archuleta Mesa in southcentral Colorado. Prior to excavating the root systems, various attributes of each tree were measured and rated. A bulldozer was employed to expose the root systems, which were examined for signs and symptoms of decay. Each root system was quantitatively assessed a level of functionality which will be related to the various aboveground measurements and ratings. We returned to the Mesa in 1992 to expose 45 more white fir as well as to quantify the proportion of root system we were able to extract utilizing the bulldozer. Studies are being carried out on the Sante Fe National Forest and Southern Ute Indian Reservation.

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PROJECT TITLE: Susceptibility of Various Tree Species Native to the Sante Fe National Forest and Exotic Western Larch (*Larix occidentalis* Nutt.) to Indigenous Isolates of *Armillaria* sp.

INVESTIGATORS/AFFILIATION: Wager, T., D. Omdal, W. Jacobi (CSU), C. Shaw III (USFS RMS)

YEAR TO BEGIN, YEAR TO END: 1989 - 1992

PROJECT DESCRIPTION: The objective of this project is to determine the relative susceptibility of various tree species native to the Sante Fe National Forest and exotic western larch to indigenous isolates of *Armillaria* sp. Bareroot and container grown 2-0 and 3-0 seedlings of western larch, blue spruce (*Picea pungens* Engelm.), white fir (*Abies concolor* (Gord. & Gled.) Lindl. ex Hildebr.), Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco), Southwestern white pine (*Pinus strobiformis* Engelm.), ponderosa pine (*Pinus ponderosa* Dougl. ex Laws.) and aspen (*Populus tremuloides* Michx.) were inoculated with 13 *Armillaria* sp. isolates (from six different host species) and a control. The isolates were collected from the Jemez District of the Sante Fe NF in September, 1988. Seedlings were inoculated with a colonized red alder stick and placed in a shade house as a totally random system within 15 blocks. The seedlings were assessed weekly for symptoms of root disease between May, 1989, and September, 1991. The trees that died during this period were removed,

and symptoms and signs of root disease were recorded. Of the 1680 seedlings that began the experiment, approximately 1400 were still alive 3 years later.

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(The following was presented to the Root Disease Committee at the Western International Forest Disease Work Conference. Vernon, British Columbia, August 5-9, 1991.)

LAMINATED ROOT ROT CONTROL: STUMP REMOVAL AND REPLANTING WITH DOUGLAS-FIR

Kenelm Russell

Forest Health Program, Washington State Department of Natural Resources, Olympia, WA

The Stearns Creek root rot control demonstration site is located on Simpson Timber Company land about 6 miles southwest of Napavine, Washington in west-central Lewis County. The objective of the trial is to monitor root rot infection and tree growth in planted Douglas-fir where stumps were either removed or not removed. Stump removal is just one way to reduce root rot infection in a new stand.

Severe Root Rot Jeopardized Douglas-fir Planted after Logging

In 1977, the residual 120-year-old Douglas-fir stand (site index 120) was logged when severe laminated root rot (*Phellinus weirii*) caused accelerated blowdown and mortality. Root rot was found in 50% or more of the trees in the large infection centers. When residual stand infection is this high, planted Douglas-fir in a replacement stand is likely to fail. Following logging, the exceptionally large stumps were extracted over most of the infection centers with a D-8 bulldozer mounted with a bush blade and splitter at a cost of $160 per acre. Fall rains shut the job down before full completion.

In the spring of 1978 the bulk of the logged unit was burned and planted with up to 500 Douglas-fir seedlings per acre, a small number of western hemlock and a few western white pines. When planting was completed, eight one-acre plots averaging 50% residual stump infection were installed in the logged area. Four plots were established in the stump removal area and four in the area where stumps remained. The stand was thinned in winter, 1989-90 to 435 trees per acre (10x10 foot spacing).

Results thus far: Nearly Twice as Many Trees are Killed on Unstumped Plots as Stumped Plots

In 1937, after nine growing seasons, there were more than twice as many root rot killed plantation trees on unstumped plots as on stumped plots (98 vs 42 trees). By 1989, the unstumped killed tree count rose to 184 compared to 103 on stumped plots. The 1991 survey showed an increase to 235 dead trees on unstumped plots and 129 trees on the stumped plots.

The ratio of unstumped to stumped mortality has changed only slightly from 1987, 1989, and 1991 surveys (ratios of 2.33, 1.79, and 1.82 respectively). Over the next decade or so, the ratio of root rot killed trees on unstumped to stumped plots is expected to slowly rise as the broken root fragments in stumped plots deteriorate and the fungus dies from lack of woody fiber. To date, all mortality has been caused by laminated root rot.

In plots that had stumps removed, an average of 50% of the previous stand was infected with laminated root rot in 1978. By 1991, after fourteen growing seasons, the plantation trees were estimated to be 15-25 feet

tall and 129 Douglas-fir seedlings were killed by laminated root rot. This mortality is the "flash" when seedling roots contact fragments of root sections left after stump pushing. A reduced amount of mortality continues subsequently, but with low stand impact.

A second stage of mortality will occur in the next few years as the rapidly expanding root systems begin to graft with each other. At this time a special precommercial thinning will be done. All suspected root rot carrying "bridge" trees between infected neighbors and healthy trees will be cut to reduce the stand to about 200 trees per acre. Where root rot is absent, normal mechanical spacing will prevail.

In the plots where stumps were not removed, there was an average of 47% of the previous stand infected with laminated root rot. In 1991, 235 Douglas-fir seedlings were killed by the disease. This mortality is expected to continue at a constant or increasing rate through the rotation. Non stocked openings are becoming more apparent with each survey. It is likely that there will not be enough crop trees at the end of the rotation. The root rot infection area will probably quadruple over the period.

Stump Removal Provides Additional Site Preparation Benefits

In 1985 the adjoining 93 acres of 120 year old timber were logged. Root rot infection centers occupying twenty-four percent of the area were marked for stump removal. The timber sold for $205/MBF with stump removal a contract requirement. The high quality logs brought premium export prices. Stump removal was only a small part of logging costs and provided adequate revenue to pay for this more expensive disease control option.

Stump removal to control laminated root rot in a new rotation of planted or naturally regenerated Douglas-fir is economically feasible. The site preparation achieved by removing stumps may benefit planting and can substitute for site preparation methods such as broadcast burning, mechanical treatment, herbicide application, or other preplant treatments that reduce unwanted vegetation competition. It is important to remember that in most cases only a relatively small portion of an infected stand needs stump removal treatment. Normal site preparation treatments may be required on the uninfected areas. Costs for combined root rot treatment and site preparation can be justified on appropriately productive sites to assure successful regeneration.

Our experience has shown that stump removal with bulldozers is too site disruptive. A large track propelled, thumb equipped backhoe does a better job with much less site impact. Loggers are using more of these machines for shovel logging where terrain permits. The addition of a thumb equipped bucket makes the large backhoe an efficient stumping machine. They are readily available in the construction business. Backhoe stump removal effectively reduces root rot inoculum and should be considered when regeneration with disease tolerant species is not feasible.

Planting Douglas-fir or other laminated root rot susceptible species without dealing with the root rot guarantees substantial losses and even failure of the future crop. Seek help from a forest pathologist for advice on stump removal as a treatment option.

Rocky Mountain Region Report

1. New and Continuing Projects

A. Forest Disease Surveys-General

92-A- Forest Health Monitoring Plot Installation (D. Johnson, Mike Schomaker)

88-A-1 Evaluation of Site Factors Involved with Aspen Sprout Mortality (P. Angwin, W. Jacobi)

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

90-D-2 Root Disease Impact Monitoring (P. Angwin, D. Johnson)

79-D-1 Surveys of Root Diseases in Managed Conifer Stands in R-2 (P. Angwin)

79-D-5 Spread of *Armillaria* spp. Disease Centers in Managed Pine Stands (P. Angwin)

F. Stem Diseases: Malformations, Witches'-Brooms, Dwarf Mistletoes, Etc.

85-F-5 Silvicultural Control of Dwarf Mistletoe in Young Lodgepole Pine Stands (B. Geils, D. Johnson, F. Hawksworth)

86-F-1 Evaluation of Ethephon as a Control of Dwarf Mistletoes in High Use Recreation Forests (D. Johnson)

K. Miscellaneous Studies

92-K- Effectiveness of Fire for Site Preparation in Seral Aspen in Western Colorado (P. Angwin, W. Shepperd)

90-K-1 Vegetation Management Planning in Developed Recreation Sites (D. Johnson, P. Angwin, M. Sharon)

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Business Meeting Minutes

Prepared by Ellen Michaels Goheen

Chairman Duncan Morrison convened the WIFDWC business meeting July 17, 1992 in Durango, Colorado.

Charlie Driver was recognized as a new honorary life member.

The minutes of the business meeting of the 1991 WIFDWC were accepted as written.

Ken Russell presented the Treasurer's Report which was approved by the members. A detailed version of that report is included in these proceedings. The need for a "changing of the guard" to cosign checks with Ken was discussed. Fields Cobb will be replaced by Dave Shaw.

Frank Hawksworth has updated the Index of WIFDWC proceedings. The members agreed to print the index as a separate publication and mail it out with the 1992 proceedings. The index will then be treated as are regular proceedings and sold to nonmembers.

A lively discussion ensued regarding the location of the 1994 WIFDWC. Proposals for meeting in Kalispell, MT or the Hood River area of WA/OR were already on the table from the 1991 WIFDWC, as well as an invitation to meet jointly with the entomologists. Because the members had agreed at the 1990 WIFDWC that meeting with the entomologists approximately every 5 years or so was a good idea, a motion was made and seconded to accept the invitation to meet jointly in Albuquerque, NM during March of 1994. This motion passed unanimously. A suggestion was made (Mark Schultz, Dave Conklin...are you listening?) to encourage the program chairs and local arrangements committees to provide the opportunity to meet as separate groups during the joint meeting.

A motion was made and seconded to meet in the Hood River area in 1995. After the relative merits of Kalispell,MT (Glacier PK, proximity to the Canadian border, etc.) and the Hood River area (Columbia River Gorge, humungous fungus, etc.) were discussed, the motion was withdrawn. The two sites were offered to the members for a vote. Kalispell:18, Hood River:13. The 1995 WIFDWC will be held in Kalispell.

The 1993 WIFDWC will be held in Boise, ID (despite the fact that no one from the Boise field Office was here to give us any information). A suggestion was made to send the folks in Boise a message encouraging a September meeting.

Duncan Morrison and Everett Hansen owned up to being the nominating (or is it railroading?) committee for new officers. The lucky recruits were approved by the members:

Chair: Willis Littke
Secretary: James Allison
Program Chair: Fred Baker

Duncan Morrison encouraged those preparing the next and future programs to allow more time for group discussion during and after the presentation of prepared material. There seem to be few opportunities for open and frank discussion at other meetings and WIFDWC was founded upon that concept. Panel moderators should ensure that adequate time is allowed to discuss the issues at hand.

Terry Shaw requested that new (and all future) officers do whatever possible to encourage the retirees to attend WIFDWC meetings. Special invitations and reduced registration fees are some suggestions. Earl Nelson and Jim Hoffman are members of a committee that was formed to encourage participation by

these valuable (and lively) members. This committee should work closely with the officers and local arrangements committees to ensure that invitations are extended.

Special thanks were offered to Pete Angwin for the excellent local arrangements, the train trip and to his "wicked" side in providing the beverages at the banquet. Also thanks to Dave Johnson and Ken Lister for the great Mesa Verde field trip, to Terry Shaw for developing a thought-provoking program and to Susan Frankel for pulling it all together and getting the information to us.

The meeting was adjourned before lunch.

Treasurer's Report

Ken Russell

Balance recorded at close of 39th meeting in Vernon	$2780.75
Proceedings: Printing costs was paid courtesy of B.C. Ministry of Forests (The $1400 estimate shown in the 39th report is added back into the account as unspent)	$1400.00
Interest Paid from July 1,1991 through June 30,1992	$ 215.11
Miscellaneous proceedings sales (19) 1/1/92 - 12/31/92	$ 190.00
Registration refund to Beth Wilhite (cancelled attendance)	($ 56.00)
Sub-Total	$4529.86

WIFDWC transactions at Durango Meeting

Net receipts	$6164.25

Meeting participants

Regular	71
Student	9
Retirees	4
Spouses	*13*
Total	97

Expenses:	($5013.45)
Proceedings printing cost estimate (160 copies)	($2000)
Balance at the close of 40th Meeting in Durango	$3680.66

Funds held in account 936258-3, Washington State Employee's Credit Union. PO Box WESCU, Olympia, WA 98507. Phone (206) 943-7911. Official signatures for withdrawing funds are Walt Thies, Ken Russell and Fields Cobb.

FOREST PATHOLOGY TRIVIAL PURSUIT III

By Frank G. Hawksworth and Charles G. Shaw, III

1. What WIFDWCers attended our host institution, Fort Lewis College, here in Durango?
   (Mary Lou Fairweather, Tracy Wager, and Ralph Zentz)

2. What widespread disease of Colorado pinyon was first studied near Durango?
   (Black stain root disease was found at nearby Mesa Verde National Park by J. L. Mielke in 1942, it was found on singleleaf pinyon in California the year before - see Wagener and Mielke, Plant Disease Reporter 45:831, 1961)

3. Who authored the first, and the last, in the classic Canadian series "Studies in Forest Pathology?"
   (Part I was by A. W. McCallum on decay of balsam fir (Can. Dept. Agric. Bull. 104, 1928); the last, Part XXV, was by R. E. Foster and A. L. S. Johnson, on sampling diseases in Douglas-fir plantations (Can. Dept. For. Publ. 1101, 1963)

4. What famous mistletoer co-authored a publication with his mother-in-law?
   (Del Wiens and Mary DeDecker,
   Madrono 21:395-402, 1972)

5. What mushroom has been revered as a good luck symbol?
   (The poisonous *Amanita muscaria*, along with four-leaf clover, mistletoe, horseshoes, swastikas, pigs, and chimney sweeps, was considered to be good luck New Year's symbol in turn-of-the century Germany)

6. What plant disease has a "patron saint?"
   (The position description of the Roman God Robigus included protecting crops from rust fungi (with our thanks to Classics Scholar Roger Peterson)

7. What WIFDWCer's mother wrote a paper on mistletoe?
   (Michael Marsden's mother authored a popular article on mistletoe in America Magazine 26:2-7, 1974)

8. What WIFDWCer's grandmother taught botany at Washington State College?
   (John Laut's grandmother taught there in the 1890's)

9. What WIFDWCer's father published a paper on beech bark disease?
   (Greg Filip)

10. What is "glassy fir?"
    (A term used by Hermann von Schrenk for wetwood in balsam fir - Missouri Bot. Garden Annual Rept. 16: 117-120, 1905)

11. Who wrote the first North American book on tree diseases?
    (The first book exclusively on tree diseases was the 1918 "Manual of Tree Diseases" by W. Howard Rankin of Cornell University. However, Dick Krebill notes that Fernow's 1910 book on "The Care of Trees in Lawn, Street and Park" covers several tree diseases.)

12. What WIFDWCer's father served in the Ukranian army?
(Borys Tkacz)

13. And what WIFDWCer's grandfather served in the Russian navy?
(Greg Filip)

14. What is "Woodgate" gall rust?
(An apparent introduction of western gall rust on Scots pine near Woodgate, New York - J. S. Boyce, Forest Science 3: 225-234, 1957)

15. Who included this statement in an acknowledgement?
"I thank Dr. Parmeter for keeping me out of the army long enough to complete this work."
(L. Felix, in his 1970 Ph.D. dissertation on white fir mistletoe, University of California)

16. What WIFDWCer is a self-avowed "crud chaser from the twilight zone?
(Mike/Ed Sharon of the Rocky Mountain Region FPM)

17. What forest pathologist grew up with the "Indigo Girls"?
(Jane Taylor)

18. What two forest pathologists had fathers who worked for the Santa Fe Railroad?
(Bob Gilbertson and Mary Lou Fairweather)

19. What is partridge wood?
(This is a common name for oak wood decayed by the fungus *Stereum frustulosum* - J. S. Boyce, Forest Pathology, 1961, p. 404)

20. When was the term "parasite" first used?
(According to Horsfal and Cowling in Plant Disease: An Advanced Treatise, Vol. 1: 11-33, 1977, this was first used by Albertus Magnus in about 1200 for mistletoe. However, Terry Shaw will submit a minority report disputing this claim and will push for the old Roman dogs under the table story.)

21. What famous WIFDWCer and philosopher made the keen observation that "Life is an unending pending?"
(Recent retiree Dick Parmeter)

22. Who stated in a 1918 paper that this is the first of a series of papers on the taxonomy of dwarf mistletoes, and for which the second part hasn't yet appeared?
(The Pioneer Arceuthobiologist James R. Weir (Botanical Gazette 56:1, 1918).....and, perhaps this will help take the heat off one F. G. Hawksworth who published Part I of a series in 1965, and for which Part II is still being planned.)

23. What tree disease agent has been honored as an official State Emblem?
(Mistletoe was designated as the State Flower of Oklahoma in 1898, the first State Flower)

24. What do these folks have in common - Bill Ciesla, Jack Barry, and Bob Young?
(They were the original cast of MAG (Methods Application Gang), when it was established in Davis, California in 1975: Bill Ciesla was the Chief, and the technical staff comprised pesticide specialist Jack Barry and statistician Bob Young. Pathologist Dave Drummond and entomologist Bill Klein joined the next year. MAG moved to Fort Collins, Colorado, in about 1982.)

25. Who first attempted to breed disease-resistant forest trees?
(No doubt we will get a lot of flak over this one, but the pioneer US Forest Service silviculturalist, Carlos Bates, was one of the first (if not the first). He propagated and outplanted ponderosa pines thought

to be resistant to dwarf mistletoe in Colorado in the late 1920's (J. Forestry 25: 130-144, 1927). These plantings were examined nearly 50 years later by Hawksworth and Edminster but the presumed resistance has not held up)

26. What are the elevations of the lowest, and highest, dwarf mistletoes?
(*Arceuthobium tsugense* on western hemlock, *A. littorum* on Monterey and bishop pines, and *A. pusillum* on white spruce (Maine) and black spruce (Newfoundland) all occur at about metric sea level. The highest species in Canada is *A. americanum* on lodgepole pine at about 6,300 feet (1,920 m) in southwest Alberta and in the US the same species ranges up to 11,000 feet (3,350 m) in central Colorado. The highest dwarf mistletoes anywhere are at about 13,400 feet (4,100 m); a height reached by both *A. globosum* on timberline pines in central Mexico (in fact, one collection label lists it "at timberline and above"!) and *A. sichuanense* on spruce in southwestern China.)

27. What is a more polite synonym for "bear wipe?"
("Bear wipe", or as Bob Gilbertson prefers "bilious elk disease," is one of the printable names that have been used for brown felt blight of high-elevation conifers caused by *Neopeckia coulteri* or *Herpotrichia nigra*.)

28. Who played in a band called "Doug and the Slugs" while he was in graduate school?
(Borys Tkacz at Yea Beaver U)

29. What mycologist published on a group of tree rusts over a 56-year period?
(F. D. Kern first wrote on the genus *Gymnosporanguim* in the Bulletin of Torrey Botanical Club 35: 499-511, 1908 and updated his research on the genus in the Memoirs of the New York Botanic Garden 10: 305-311, 1964.)

30. Who first studied the correlation between a tree disease and understory vegetation (not counting alternate rust hosts)?
(Eleanor Dowding (J. Ecology 17: 82-105, 1929) noted that *Arceuthobium americanum* on jack pine in northern Alberta was much more common in the pine-moss association than in the pine-heath association.)

31. What is *Fomes fuzzi-sandozii*?
(This is a facetious name for *Fomes nobilissimus* (= *Oxyporus nobilissimus*), which was coined by foresters to honor the Sandoz brothers who first found this huge, hairy conk on noble fir in western Washington - see W. B. Cooke, Mycologia 41:442, 1949. Also, rumor has it that this may be the first fungus to be placed on the endangered species list.)

32. What is the only tree pathogen mentioned in the Guinness Book of World Records?
(According to the 1992 version, the heaviest fungus is a 72-pound conk of *Polyporus frondosus* collected in Ohio in 1976. Apparently these folks haven't heard of the 300-pound conks of *Fomes nobilissimus* collected on noble fir in Lewis County, Washington (W. B. Cooke, Mycologia 41: 442-455, 1949) or the 5-foot wide, 300 pound conk of *Fomes pinicola* found by Buck Buchanan in western Washington in 1948.)

33. And what is said to be the most humongous fungus?
(According to M. L. Smith et al. (*Nature*, April 1992), this is a 30-acre spread of *Armillaria* in a hardwood forest in northern Michigan that is said to be more than 1,500 years old. However, Shaw and Co. in their *Armillaria* book describe a 1,500 acre, and presumably much older, infection center southeast of Mt. Adams in Washington State.)

34. What WIFDWCer and WIFDWICer's father wrote on the Taxonomy and Evolution of the Downy Mildews?
(C. Gardner Shaw wrote a chapter on this subject in D. M. Spenser's book on the downy mildews.)

35. What is the first North American forest pest management agency to adopt the new "Forest Health" handle?
(According to Ken Russell, it is the State of Washington DNR/Forest Health, which adopted the name in July, 1989. The New Zealand group adopted the name sometime earlier.)

36. Who were the first forest pathologists assigned to the western US Forest Service Regions?
(E. P. Meinecke was assigned to the California Region in 1910 by the Office of Investigations in Forest Pathology. Later the Intermountain Region was also assigned to his area of responsibility. Pathologists were next assigned to the Northern and Southwestern Regions in 1911 although J. R. Weir did not start in Missoula and W. H. Long in Albuquerque until 1913. J. S. Boyce was assigned to Portland as the first Pacific Northwest Region pathologist in 1920. The first pathologist permanently assigned to the Intermountain Region was J. L. Mielke (Logan in 1950) and Ross Davidson was the first pathologist in the Rocky Mountain Region (Fort Collins in 1951). The first pathologist in the Alaska Region was Tom Laurent who moved to Juneau in 1956, although he was not assigned pathology duties until 1961.)

37. Which famous forest pathologist was such an expert in Indian lore that he was asked to coach a group of ceremonial Indian dancers for a presidential visit to Glacier National Park?
(E. E. Hubert was asked to do this for a visit by President Roosevelt to the Park in 1934 - see Buchanan's 1976 history of forest pathology in the West, p. 85.)

38. Who were the first forest pathologists employed by private industry in the West?
(H. von Schrenk in the early part of the century and E. E. Hubert in the 1920's were forest products pathologists for wood preserving companies. The first "forest" pathologists were T. S. Buchanan who was employed by the Weyerhaeuser Company in western Washington in 1946 to 1947, and Keith Shea by the same company from 1956 to 1966.)

39. Who was the first professor of forest pathology in the West?
(Henry Schmitz was appointed Professor of Forest Pathology and wood products pathology at the University of Idaho in 1919. He later became a Dean at the University of Minnesota and President of the University of Washington.)

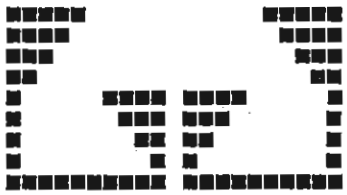
40. What WIFDWCer cracked the ribs of his supervisor whilst practicing the Heimlich Maneuver in a CPR Class?
(Cracker - Brian Geils; crackee - Frank Hawksworth)

41. What WIFDWCer recently wrote an article on wood decay conks as guardians of graves?
(Bob Gilbertson et al. describe carved *Fomes laricis* conks on shaman graves of Northwest indigenous peoples - Mycologia 84: 119-124, 1992.)

42. What are "churns," which are described from the Chugach National Forest, Alaska, in a noted forest pathology textbook?
(Dow Baxter in his "Pathology in Forest Practice" illustrates mistletoe-caused burls (or "churns") on the boles of western hemlock. However, conventional wisdom (a.k.a. Tom Laurent, Terry Shaw and Paul Hennon) indicates that the indigenous "mooseletoe" beans are as close to mistletoe as there is on the Chugach National Forest.)

43. What WIFDWCer, when asked if he skied, replied "not since I moved to Colorado?"
(R. C. Thobium)

44. Only one Canadian WIFDWC has been held outside British Columbia, Where? When?
(Ten WIFDWC's have been held in B. C.; the 9th conference was held in beautiful Banff, Alberta in 1961.)



MEETING LOCATIONS AND EXECUTIVE COMMITTEES

Yr.	Location	Chairman	Secretary/ Treasurer	Program Chairman	Local Arrangements
53	Victoria, BC	R.Foster	--	--	--
54	Berkeley, CA	W.Wagener	P.Lightle	--	--
55	Spokane, WA	V.Nordin	C.Leaphart	G.Thomas	--
56	El Paso, TX	L.Gill	R.Davidson	V.Nordin	--
57	Salem, OR	G.Thomas	T.Childs	R.Gilbertson	--
58	Vancouver, BC	J.Kimmey	H.Offord	A.Parker	--
59	Pullman, WA	H.Offord	R.Foster	C.Shaw	--
60	Centralia, WA	A.Parker	F.Hawksworth	J.Parmeter	K.Shea
61	Banff, ALB	F.Hawksworth	J.Parmeter	A.Molnar	G.Thomas
62	Victoria, BC	J.Parmeter	C.Shaw	K.Shea	R.McMinn
63	Jackson, WY	C.Shaw	J.Bier	R.Scharpf	L.Farmer
64	Berkeley,CA	K.Shea	R.Scharpf	C.Leaphart	H.Offord
65	Kelowna, BC	J.Bier	H.Whitney	R.Bega	A.Molnar
66	Bend, OR	C.Leaphart	D.Graham	G.Pentland	D.Graham
67	Santa Fe, NM	A.Molnar	E.Wicker	L.Weir	P.Lightle
68	Coeur d'Alene, ID	S.Andrews	R.McMinn	J.Stewart	C.Leaphart
69	Olympia, WA	G.Wallis	R.Gilbertson	F.Hawksworth	K.Russell
70	Harrison Hot Sp, BC	R.Scharpf	H.Toko	A.Harvey	J.Roff
71	Medford, OR	J.Baranyay	D.Graham	R.Smith	H.Bynum
72	Victoria, BC	P.Lightle	A.McCain	L.Weir	D.Morrison
73	Estes Park, CO	E.Wicker	R.Loomis	R.Gilbertson	J.Laut
74	Monterey, CA	R.Bega	D.Hocking	J.Parmeter	--
75	Missoula, MT	H.Whitney	J.Byler	E.Wicker	O.Dooling
76	Coos Bay, OR	L.Roth	K.Russell	L.Weir	J.Hadfield
77	Victoria, BC	D.Graham	J.Laut	E.Nelson	J.Bloomberg
78	Tucson, AZ	R.Smith	D.Drummond	L.Weir	R.Gilbertson
79	Salem, OR	T.Laurent	T.Hinds	B.van der Kamp	L.Weir
80	Pingree Park, CO	R.Gilbertson	O.Dooling	J.Laut	M.Schomaker
81	Vernon, BC	L.Weir	C.Shaw III	J.Schwandt	D.Morrison/R.Hunt
82	Fallen Leaf Lk., CA	W.Bloomberg	W.Jacobi	E. Hansen	F.Cobb/J.Parmeter
83	Coeur d'Alene, ID	J.Laut	S.Dubreuil	D.Johnson	J.Schwandt/J.Byler
84	Taos, NM	T.Hinds	R.Hunt	J.Byler	J.Beatty/E.Wood
85	Olympia, WA	F.Cobb	W.Thies	R.Edmonds	K.Russell
86	Juneau, AK	K.Russell	S.Cooley	J.Laut	C.G.Shaw III
87	Nanaimo, BC	J.Muir	G.DeNitto	J.Beatty	J.Kumi
88	Park City, UT	J.Byler	B.van der Kamp	J.Pronos	F.Baker
89	Bend, OR	D.Goheen	R.James	E.Hansen	A.Kanaskie
90	Redding, CA	R.Hunt	J.Hoffman	M.Marosy	G.DeNitto
91	Vernon, B.C.	A.McCain	J.Muir	R.Hunt	H.Merler
92	Durango, CO	D.Morrison	S.Frankel	C.Shaw III	P.Angwin
93	Boise, ID	W.Littke	J.Allison	F.Baker	J.Hoffman

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Year	Location	Winner
1957	Salem, Oregon	Stuie Andrews
1958	Vancouver, BC	Stuie Andrews
1959	Pullman, Washington	Don Leaphart
1960	Centralia, Washington	Keith Shea
1961	Banff, Alberta	Phil Thomas
1962	Victoria, BC	Toby Childs
1963	Jackson, Wyoming	Alex Molnar
1964	Berkeley, California	Reed Miller
1965	Kelowna, BC	Art Parker
1966	Bend, Oregon	Gardner Shaw
1967	Sante Fe, New Mexico	Larry Weir
1968	Coeur d'Alene, Idaho	Bob Scharpf
1969	Olympia, Washington	Dick Parmeter
1970	Harrison Hot Springs, BC	Jim Kimmey
1971	Medford, Oregon	Ed Wicker
1972	Victoria, BC	Vivian Muir
1973	Estes Park, Colorado	Tom Laurent
1974	Monterey, California	Bob Bega
1975	Missoula, Montana	Art McCain
1976	Coos Bay, Oregon	----------
1977	Victoria, BC	Ray Foster
1978	Tucson, Arizona	John Hopkins
1979	Salem, Oregon	Oscar Dooling
1980	Pingree Park, Colorado	Tommy Hinds
1981	Vernon, BC	Fields Cobb
1982	Fallen Leaf Lake, California	John Laut
1983	Coeur d'Alene, Idaho	Bob Gilbertson
1984	Taos, New Mexico	Terry Shaw
1985	Olympia, Washington	Fred Baker
1986	Juneau, Alaska	Edna Miller
1987	Nanaimo, BC	Sally Cooley
1988	Park City, Utah	Don Goheen
1989	Bend, Oregon	Ellen Michaels-Goheen
1990	Redding, California	Frank Hawksworth
1991	Vernon, B.C.	Willis Littke
1992	Durango, CO	Pete Angwin

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