PROCEEDINGS OF THE 49th ANNUAL WESTERN INTERNATIONAL FOREST DISEASE WORK CONFERENCE

Carmel, California
September 10-14, 2001

Proceedings of the 49th Annual Western International Forest Disease Work Conference

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Compiled by:
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Proceedings of the Forty-Ninth Western International Forest Disease Work Conference
Carmel, California September 2001

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Program

Monday – September 10

12:00 – 5:00 pm Western Nursery Pathology Workshop

4:00 – 8:00 pm Registration

6:00 - ?? pm Welcome Social for WIFDWC and North American Forestry Commission, Insect and Disease Study Group

Tuesday – September 11

7:30 am Registration (continued)

7:00 am Dwarf Mistletoe Committee Breakfast

8:30 am Chairman's Welcome and Announcements – Dave Johnson (retired, USDA Forest Service, Denver, CO)

9:00 am Regional Reports

10:00 am Coffee Break

10:30 am Regional Reports (continued)

11:00 am **Special Papers:** Moderator – Michael McWilliams (Oregon Department of Forestry, Salem)

Pitch canker: testing the ecological limits in California. Tom Gordon (University of California, Davis)

Snag creation, fungal colonization and bird usage in Oregon and location of probable nesting sites in variable aged Douglas-fir stands with laminated root rot gaps. Willis Littke (Weyerhauser Forestry Research, Centralia, Washington)

12:00 pm Hazard Tree Committee Luncheon

1:30 pm **Panel: Sudden Oak Death.** Moderator – Susan Frankel (USDA Forest Service, Vallejo, CA)

An overview of Sudden Oak Death in California. David Rizzo (University of California, Davis)

Sudden Oak Death in Oregon. Ellen Goheen (USDA Forest Service, Central Point, OR) and Nancy Osterbauer (Oregon Department of Agriculture, Salem)

3:00 pm Coffee Break

3:30 pm **Special Papers:** Moderator - Marylou Fairweather (USDA Forest Service, Flagstaff, AZ)

Oak Decline and ecosystem health in eastern hardwood forests. Steve Oak (USDA Forest Service, Asheville, NC)

Carbon and nitrogen nutrition of the canker fungus *Natrassia magniferae*. Marianne Elliott (University of Washington, Seattle)

Breeding for resistance to *Phytophthora lateralis* in Port-Orford-cedar: current status amd considerations for developing durable resistance. Richard Sniezko (USDA Forest Service, Cottage Grove, OR) and Everett Hansen (Oregon State University, Corvallis)

5:00 pm Adjourn

7:00 pm **Poster Session**

Wednesday – September 12

8:30 am **Field Trip** – Managing pathogens on state and private lands, featuring Sudden Oak Death, Pitch Canker and Western Gall Rust

5:00 pm Return to Carmel

Thursday – September 13

7:00 am Root Disease Committee Breakfast

8:30 am **Panel: Rethinking *Phytophthora*.** Moderator – Everett Hansen (Oregon State University, Corvallis)

Oomycete-mediated mortality of tropical tree seedlings: implications for density-dependent regulation of tropical tree diversity. Jenny Davidson (USDA Forest Service, Davis, CA)

Factors governing the spread of *Phytophthora lateralis* infecting Port-Orford-cedar. Matthew J. Kauffman and Erik S. Jules (Humboldt State University, Arcata, CA)

Phytophthora and Oak Decline in Europe. Claude Delatour (INRA Centre de Nancy, Laboratoire de Pathologie Forestière, France)

10:00 am Coffee Break

10:30 am Rethinking *Phytophthora* and Sudden Oak Death discussion: Moderator – Everett Hansen

11:00 am **Special Papers:** Moderator - John Pronos (USDA Forest Service, Sonora, CA)

Molecular approaches involved in the discovery phase of Sudden Oak Death: implications for diagnostics, pathogen biology, and origins of the newly described *Phytophthora ramorum*. Matteo Garbelotto (University of California, Berkeley)

Ecological relationships of root diseases in Southwest Oregon. Ellen Goheen, Don Goheen and Katy Marshall (USDA Forest Service, Central Point, OR)

12:00 pm Rust Committee Luncheon

1:30 pm **Panel: Swiss Needle Cast – What we didn't know.** Moderator – Jeff Stone (Oregon State University, Corvallis)

Overview of Swiss Needle Cast research and monitoring in Oregon. Jeff Stone and Alan Kanaskie (Oregon Department of Forestry, Salem)

Systematics of the Douglas-fir Swiss Needle Cast pathogen *Phaeocryptopus gaeumannii*. Lori Winton (Oregon State University, Corvallis)

The physiology of Douglas-fir infected with *P. gaeumannii*. Dan Manter (Oregon State University, Corvallis)

3:00 pm Coffee break

3:30 pm Business meeting

5:00 pm Group Photo

6:30 pm Banquet

Friday – September 14

7:30 am Disease Control Committee breakfast

8:30 am **Panel: Detecting and Monitoring Forest Pathogens – Interpreting spatial data, roadside surveys, and inventory plots.** Moderator – Sally Campbell (USDA Forest Service, Portland, OR)

Ground-based Surveys: Designing sampling methods for newly introduced diseases or other rare, unevenly distributed organisms. Wally Mark (CalPoly San Luis Obispo, Davenport, CA)

Aerial Surveys: Using ground sampling to assess accuracy and draw inferences from survey data. Alan Kanaskie and Mike McWilliams (Oregon Department of Forestry, Salem)

Remote Sensing: Use of satellite imagery in conjunction with other data (aerial survey, inventory plots, validation sampling) to assess disease status and change across large landscapes. Lisa Levien (USDA Forest Service, Sacramento, CA)

10:00 am Coffee break

10:30 am **Special Papers:** Moderator - Pete Angwin (USDA Forest Service, Redding, CA)

Whitebark pine and white pine blister rust in British Columbia. Stefan Zeglen (British Columbia Ministry of Forests, Vancouver Region, CANADA)

The Role of *Ribes*: white pine blister rust in the Greater Yellowstone Area whitebark pine forests. Maria Newcomb (University of Montana, Missoula)

Impact of prescribed fires in ponderosa pine stands in the southern Blue Mountains on various components of the ecosystem – three years post-fire. Walt Thies and Christine Niwa (USDA Forest Service, Corvallis, OR)

11:30 am Meeting Adjourns

CHAIRPERSON'S REMARKS

Dave Johnson, Retired
USDA Forest Service, Denver, CO

Opening Statements

Welcome to Carmel and the 49th annual meeting of the Western International Forest Disease Work Conference. Welcome also to members of the North American Forestry Commission Insect and Disease Study Group who will be sharing field trip and panel sessions with us this week. Please recognize the excellent work of this years committee members for putting together an interesting program and for providing this facility for us:
Local arrangements – Susan Frankel
Program – Alan Kanaskie
Secretary – Katy Marshall
Treasurer – John Schwandt
Webmaster – Judy Adams

Announcements –

To my knowledge no members have passed away this past year. At this time if anyone has any other information, please inform the group. It appears that our group is intact this year. Thank you.

The business meeting notes from last year are available. Please look these over before Thursday's business meeting that will be held at 3:30 PM.

After my remarks we will have regional reports. Please designate one person from each office to give a brief summary that includes staff/organizational changes, vacant positions (for the benefit of our young, eager job seekers) and major projects.

As I mentioned earlier, this is our 49th annual meeting. As the world rushed to California in 1849 and the phrase "forty-niner" was coined, we also come to California, but for different reasons. We come to seek knowledge and companionship. The forty-niner was an "out-of stater" (as many of us) who gave up his home, his job and his girl to "see the elephant" (hopefully none of you have!), that is the ultimate in adventure and hardship. Forty thousand prospectors poured into California by the end of 1849. A handful returned home; but most remained- with or without gold. About two-fifths came by sea, a 17,000 mile journey around Cape Horn, or by sea and then across Panama by foot or muleback and then up the Pacific Coast arriving in San Francisco after seven months journey. None of us today have had to endure such hardships, but hopefully we too are full of hope and are eager to fill ourselves with knowledge in place of gold!

If you are interested in reading more about the gold rush era and the many individuals that made contributions to the opening of the western United States, I recommend the book by Irving Stone " Men to Match My Mountains". The author describes men that braved a wilderness and endured hardships. Before me today, as I look over this group, I too see many members who have contributed much to our science and say that we should congratulate ourselves for we are "Men to Match the Mountains!" Let's give ourselves a hand!

To reminisce a bit, my first meeting was in 1971 in Medford, Oregon – our 19th annual meeting. As a young forest pathologist and recent graduate of the University of Wisconsin, I had the opportunity to meet several members that had an important influence on my career and its direction for the next 30 years. To mention a few – Frank Hawksworth, Tommy Hinds, Earl Nelson, Jim Stewart, Larry Weir, Jim Hadfield and Dave Graham. I am forever indebted to this organization and its members for an interesting and satisfying career. My advice to all of you today is to "seize the moment", enjoy the meeting , and engage in a lively discourse with your peers. Thank you.

Concluding remarks at the end of the meeting

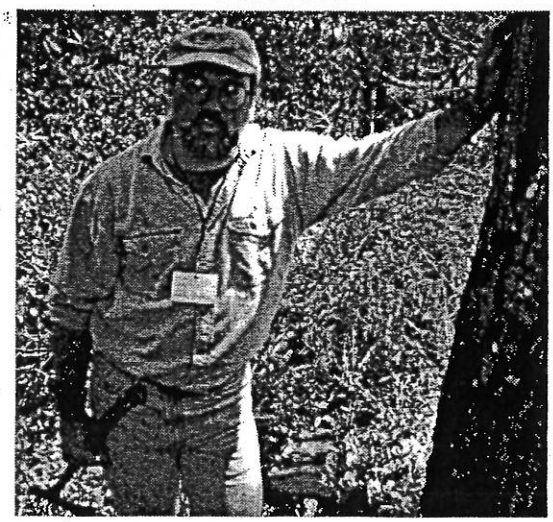
As your chair, I wish to make a few brief comments. This week is one we will never forget. A cloud of darkness has been over us, however, I hope that this meeting will not be remembered only for the darkness, but also for what we have attempted to accomplish here.

Fortunately we have had minimal impacts on our meeting and our program was almost entirely intact. Thanks to our local arrangements and program chairs for pulling this off without problems and to all our speakers.

As you return to your homes and workplaces, I wish you well. Some of us will continue to be adversely impacted by the events of this week. Our travel plans have been disrupted. Hopefully the impacts on your personal lives are minimal. I wish you all a safe trip home. Until we meet again, take care and best wishes.

Helen Maffei and Dave Johnson

Dave Rizzo



PANEL: SUDDEN OAK DEATH

Moderator: Susan Frankel, USDA Forest Service, Vallejo, CA

An Overview of Sudden Oak Death in California

David Rizzo

Department of Plant Pathology, University of California, Davis

A new canker disease of *Lithocarpus densiflorus*, *Quercus agrifolia*, *Q. kelloggii*, and *Q. parvula* var. *shrevei* in California has been shown to be caused by *Phytophthora ramorum*. The pathogen is a recently described species that was previously known only from Germany and The Netherlands on *Rhododendron* and *Viburnum*. This disease has reached epidemic proportions in mixed evergreen and redwood forests over an area along approximately 300 km of the central coast of California. The most consistent and diagnostic symptoms on larger trees are the canker s that develop before foliage symptoms become evident. Cankers have brown or black discolored bark, seep dark red sap and occur on the trunk at the root crown up to 20 m above the ground. Cankers do not enlarge below the soil line into the roots. Canker s can be over 2 m in length and are delimited by thin black zone lines in the inner bark. Foliage on affected trees often turns from a healthy green color to brown over a period of several weeks. In *L. densiflorus* saplings, *P. ramorum* was isolated from branches as small as 5 mm diameter. *Lithocarpus densiflorus* and *Q. agrifolia* inoculated with *P. ramorum* in the field and greenhouses developed symptoms similar to those of natural infections. The pathogen was re-isolated from inoculated plants, thereby confirming pathogenicity. The host range in California has been greatly expanded and now includes *Rhododendron* spp., madrone (*Arbutus menziesii*), huckleberry (*Vaccinium ovatum*), manzanita (*Arctostaphylos* spp.), California bay laurel (*Umbellularia californica*), buckeye (*Aesculus californica*), and bigleaf maple (*Acer macrophyllum*). On these hosts, *P. ramorum* causes a variety of foliar and branch symptoms. An important step in controlling this disease involves understanding how it is spread. The presence of diseased oaks at all elevations on hillsides and the above-ground nature of the disease suggest wind-blown rain or rain splash as a common mechanism for movement of spores. Although viable spores have yet to be found on infected oak tissue, other hosts may serve as sources of rain-dispersed inoculum. In the laboratory, abundant sporangia form on moistened leaves of infected bay (*Umbellularia californica*) and *Rhododendron* spp. within 72 hours. These sporangia break off and easily disperse in water. Chlamydospores were also observed on the surface of moistened bay leaves. Consistent with these results, *P. ramorum* has been recovered from rain, soil, litter and stream water from woodlands with infected oak and bay trees. Spores of *P. ramorum* do not survive drying, but in moist conditions can survive for at least one month.

Sudden Oak Death in Oregon: Detection and Eradication Efforts

Ellen Goheen[1], and Nancy Osterbauer[2]

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What is now called Sudden Oak Death or "SOD" was first reported in 1995 in Mill Valley, California. Residents of the urban-forest interface observed rather striking and seemingly spontaneous death of tanoaks in the forests close to their homes. Since that time, large numbers of tanoak, coast live oak, and black oak have died in the forests of Alameda, Marin, Mendocino, Monterey, Napa, Sonoma, Santa Clara, San Mateo, Santa Cruz, and Solano counties. Up to 80 percent of the oaks in some stands have been killed. The causal agent, *Phytophthora ramorum*, a previously undescribed species, also kills Shreve's oak, Pacific madrone, and evergreen huckleberry. *P. ramorum* has been found to cause tip dieback and leaf spotting of myrtlewood (also known as California bay-laurel), Pacific madrone, California buckeye, bigleaf maple, and rhododendron cultivars in California and European nurseries.

The Potential for Sudden Oak Death in Southwest Oregon

All of the plant species reported as hosts of the SOD *Phytophthora*, except coast live oak, Shreve's oak, and California buckeye, are important species in our area. Black oak and tanoak are key ecological components of oak woodland and coast range ecosystems in southern Oregon. Tanoak grows in mixed conifer stands on the moist slopes of the coastal mountains. It can grow on a variety of soils including serpentine soils. It also forms pure stands. Tano ak leaves and branches are collected, processed, and shipped widely for decorative purposes. Tanoak forests support many highly prized mushroom species including boletes, coral fungi, and a matsutake. Black oak is a key component of low to mid elevation forests on dry sites. It grows individually or in groves and often acts as a nurse tree to conifers. Acorns of both species are important wildlife food sources, and large trees are significant for cavity nester use. Both species have important ties to Native American cultures. Pacific madrone occurs commonly in southwest Oregon, from the drier aspects in coastal forest communities to a wide array of sites in the interior valleys. Madrone wood is dense and hard and is used in small quantities for lumber and flooring. It is a popular firewood species. The smooth reddish-orange bark, shiny green leaves, and berries contribute to its value as an ornamental species. Birds and small mammals feed on its berries. Myrtlewood is considered the most valued and best-publicized hardwood species in the western United States. The wood is beautifully grained; items made from myrtlewood are widely marketed. Native Americans used all parts of the tree for food and medicinal purposes. Myrtlewood provides food and cover for many wildlife species including birds, small mammals, and deer. It is also used in landscape plantings. Evergreen huckleberry is widely distributed from northern California through Oregon, Washington and into British Columbia. It is a community dominant throughout much of its range, is an important browse species for elk in the Coast Range and in southern Oregon, is dug for use in landscape plantings, and its branches are collected and shipped widely in floral arrangements. It is closely related to blueberries and cranberries as well as other huckleberry species and could provide the bridge for movement of the *P. ramorum* to these agricultural commodities. Rhododendron species are also widely distributed in the forests of Oregon and prized for their aesthetics. Oregon is a net exporter of cultivated rhododendrons and there are great concerns about the potential impacts of SOD to the rhododendron horticultural industry.

P. ramorum seems to prefer cool, moist conditions but has the capability of su rviving through dry periods. Thus Oregon's climate, particularly in the Southwest Oregon coastal zone would appear to be quite favorable to the disease.

Many possibilities exist for movement of plant material and soil from infested areas into and around Oregon. Oak firewood is routinely sold as a commercial product in stores and cut for individual homeowner use. Lumber, wood chips, and other wood products move readily through Southwest Oregon. Boughs and leaves of host plants are collected and sold wor ldwide. Mushroom gatherers move among forest stands. Hikers, mountain bikers, hunters, and other recreationists have access to acres and acres of forestlands. Nursery products are shipped widely.

Southwest Oregon has the hosts, the climatic conditions p referred by the pathogen, and many potential pathways for its movement; chances of introduction and establishment appear high. If established, *P. ramorum* would pose an especially great hazard to host ecosystem components in Southwest Oregon.

Sudden Oak Death Surveys

Ground-based surveys to detect Sudden Oak Death were begun in 2000 as a cooperative effort by the Oregon Department of Agriculture, Oregon Department of Forestry, and the USDA Forest Service. Gypsy moth trappers employed by ODA evaluated ho st species for SOD symptoms in the vicinity of traps in urban, interface, and wildland settings throughout the Southwest Oregon Coastal region. Pathologists with ODF and USDA Forest Service drove state and federal forest roads and evaluated roadside tanoa ks. As a part of an evaluation of permanent ecology plots, USDA Forest Service pathologists increased their sampling intensity in tanoak plant associations and collected samples from "suspect" tanoak. Isolations were done from bleeding cankers on tanoak. No *Phytophthora* spp. were recovered in these efforts.

As demonstrated in California and Europe, *P. ramorum* can spread via infected rhododendrons. This raised concerns about Oregon's rhododendron nursery stock. ODA Nursery Inspectors examined rhododendrons in 67 grower nurseries for Phytophthora foliar blight symptoms. A total of 2,254 samples were collected from the nurseries and brought to the lab for processing. Leaf and stem samples were placed both in moisture chambers and into a Phytophthora -selective medium (PARP). Using light microscopy, the samples in the moisture chambers were examined for pathogen growth after 24 to 48 hr while the samples in the PARP medium were examined after 4 to 10 days. All *Phytophthora* spp. recovered were identified to species using standard procedures. *Phytophthora ramorum* was not recovered from any of the samples. However, other *Phytophthora* spp., most notably *P. syringae, P. cactorum,* and *P. citricola,* were recovered from samples collected at 30 of the nurserie s. Multiple *Phytophthora* spp. were found at six of the 30 nurseries. These results indicate the laboratory procedures used would have detected *P. ramorum* if it were present. Based on these results, Oregon's grower nurseries remain free from *P. ramorum*.

A special aerial detection survey for SOD was done in Southwest Oregon in late July 2001. The area surveyed was selected based on influence of coastal environmental conditions, high proportion of tanoak in the forest, and proximity to heavily used tran sportation routes between California and Oregon. Aerial observers in an airplane looked for a signature of orange to light brown-to tan-colored individual trees or patches of tanoak. Twenty -two patches or individual dead tanoak were mapped. A helicopter was then used to more closely view the affected trees and mark an accurate GPS location. Suspect sites were visited and evaluated within two weeks. Aside from SOD symptoms, Armillaria root disease and mechanical damage were frequently observed. Isolations from symptomatic trees were made onto *Phytophthora*-selective media and

cultures that grew from isolations were checked against known *P. ramorum* cultures and *P. ramorum* DNA. SOD symptoms were not common on the other SOD hosts that were present on sites. At a few locations samples were taken from symptomatic evergreen huckleberry and wild rhododendron.

As of September 18, 2001, five sites in Curry County, Oregon were identified as positive for the presence of *P. ramorum*. Tanoak, evergreen huckleberry, and Pacific rhododendron have been found infected. *P. ramorum* was also recovered from soil in the vicinity of infected trees. With the cooperation of the landowners involved, the ODA is proceeding with eradication efforts at all of the positive sites. The infection centers were delimited based upon symptoms observed on the host species present (tanoak, rhododendron, Oregon myrtle, and evergreen huckleberry). A 50 to 100 ft buffer zone was then placed around the active infection centers. The entire area (buffer zone plus infection center) is considered the eradication zone. All host plants within the eradication zone will be cut, bucked, and piled within the zone. This step is already underway at three of the five infection sites. After the materials have dried sufficiently in the fall, the materials will be subjected to a prescribed burn. The prescription for the burn will require a flame hot enough to burn the bark and outer layers of the largest woody debris. A broadcast burn to destroy any missed foliage or other small materials is planned for the spring. The sites will be surveyed for the presence of the pathogen for a period of two years following the burn(s). The sites must remain free of the pathogen for two years before the pathogen can be declared eradicated.

Ground-based and aerial surveys for SOD will continue throughout the host type in Southwest Oregon in the coming months and years. Any new disease centers that are found will be considered for treatment.

PANEL: RETHINKING *PHYTOPHTHORA*

Moderator: Everett Hansen, Oregon State University, Corvallis

A positive role for *Phytophthora* in natural ecosystems: Maintenance of tropical tree species diversity

Jennifer M. Davidson

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Phytophthora remains infamous as a genus of plant pathogens causing unrecoverable destruction of natural ecosystems and billions of do llars of damage to agricultural crops. Examples of significant *Phytophthora* epidemics in natural systems include *P. cinnamomi* in Australian jarrah forest (dieback) (Weste and Marks 1987); *P. lateralis* on Port Orford Cedar in Oregon and Northwest California (Hansen et al. 2000); *P. ramorum* in oak forest (Sudden Oak Death) in California and Southwest Oregon (Rizzo et al. *in press*); and a hybrid *Phytophthora* species on European alder (Brasier et al. 1999). However, in all of these well known cases, the *Phytophthora* species is thought to be introduced or the recent product of hybridization, and consequently may function as an exotic, invasive species that escapes regulation in its new environment.

Studies on the activity of native *Phytophthora* species in natural ecosystems are only just emerging. Yet, for the majority of their evolutionary history, *Phytophthora* species evolved in, and were integral parts, of natural ecosystems. Initial studi es on *Phytophthora* species in temperate ecosystems reveal that *Phytophthora* can act as a saprophyte, or be only mildly pathogenic (Hansen et al. 1988, Hansen and Delatour 1999). Additionally, *Phytophthora* species that co-evolve with natural systems may still be destructive pathogens of plants, but ones that are held in check by environmental conditions, microbial competitors, or other factors (Jung et al. 2000). As a predator of plants, *Phytophthora* may play important and beneficial roles regulating plant succession, community structure, and species diversity (Janzen 1970, Connell 1971, Dobson and Crawley 1994, Hansen 1999). In turn, the biotic and abiotic factors that regulate *Phytophthora* species in natural ecosystems may provide insight into controlling this pathogen in natural or agricultural systems where it is introduced.

In the tropics, knowledge of native forest pathogens, including *Phytophthora*, is even more scarce (Hawksworth and Rossman 1997). However, a long-standing hypothesis, first published 30 years ago, suggests that host-specific pathogens may play an especially important ecological role in tropical forests. Pathogens may help maintain tree species diversity in tropica l forests through density-dependent regulation of tree seedlings (Janzen 1970, Connell 1971, Augspurger 1983, Kitajima and Augspurger 1989, Gilbert et al. 1994, Gilbert and De Steven 1996). If pathogens have higher attack rates when conspecific seedlings are at high density (like an agricultural monoculture), then seedlings of a given tree species will not survive in areas where that species is common, but may escape and establish in areas where that species is rare. In this way, the over all diversity of the forest may be maintained.

In this study, I investigated the possibility that native oomycete pathogens help maintain tree species diversity in a lowland tropical rainforest in Panamá through density -dependent regulation of their host: seedlings of *Anacardium excelusum* (wild cashew). *Phytophthora heveae* and several *Pythium* species were isolated from dying *Anacardium* seedlings and verified to be pathogenic using Koch's postulates. The *Pythium* species incuded *P. vexans*, *P. splendens*, and *P. chamaehyphon*. However, *P. vexans* constituted over 70% of the *Pythium* isolates. The activity of these *Phytophthora* and *Pythium* pathogens was monitored by planting *Anacardium* study seedlings into sites associated with mother *Anacardium* trees during 1996 (ten sites) and 1997 (twelve sites). These sites contained different background densities of naturally occurring *Anacardium* seedlings so that the effect of seedling density on pathogen performance could be ascertained.

Results from isolating pathogens from dead or nearly dead seedlings showed that overall pathogen-mediated seedling mortality at sites was positively density -dependent. In other words, pathogens had greater activity at sites with higher seedling density. However, when this overall result was broken down, the two main oomycetes, *Phytophthora heveae* and the *Pythium* assemblage dominated by *Pythium vexans* showed different responses to seedling density conditions. *Phytophthora heveae* was significantly associated with high seedling density, high mortality sites. This pathogen occurred early in the wet season when seedling density was high, and reproduced with sporangia, typically considered to be major infective propagules. In contrast, the *Pythium* assemblage was not significantly associated with high seedling density, high mortality sites. *Pythium* infection occurred throughout the wet season, and sporangia of this pathogen were not observed on field seedlings.

These results indicate that while not all seedling pathogens may serve to maintain tree species diversity in tropical forests, *Phytophthora heveae* may be a key ecological species for preserving diversity in tropical forests due to its specialization on high conspecific seedling density conditions. Thus, native *Phytophthora* species may have positive roles in natural ecosystems although they still act as plant pathogens. Future work should concentrate on the host range and specificity of *Phytophthora heveae* in these lowland tropical rainforest sites in Panamá to gain a greater understanding of how this pathogen influences overall forest dynamics of multiple tree species.

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Phytophthoras and Oaks in Europe

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A major part of the information used in this paper was obtained within the framework of the European Research Project 'Pathoak' which participants were :
Anselmi N.[1], Barbaroux C.[2,3], Barzanti P.[4], Bianco M.C.[5], Blaschke H.[6], Brasier C.[7], Bréda N.[2], Camy C.[8], Capretti P.[4], Cha J.J.[8], Delatour C. (coordinator)[8], Desprez-Loustau M.L.[9], Dreyer E.[2], Dufrêne E.[3], Dupouey J.L.[2], Häberle K.H.[6], Hansen E.[8], Heyne C.[6], Jung T.[6], Loustau D.[10], Luisi N.[5], Marçais B.[8], Matyssek R.[6], Maurel M.[9], Oβwald W.[6], Paoletti E.[11], Ponton S.[2], Ragazzi A.[4], Robin C.[9], Vannini A.[1], Vettraino A.M.[1].

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Introduction

Oak forest in Europe

Europe has a variety of climatic conditions and a variety of forest types. In the northern regions, the boreal forest consisting primarily of conifers, covers a wide area in Scandinavia and Russia. In the middle regions is the large forest of deciduous trees where pedunculate and sessile oaks (*Quercus robur* and *Q. petraea*), and beech (*Fagus silvatica*) are prevalent. At the southern limits of Europe is the Mediterranean forest where holm oak (*Q. ilex*) and cork oak (*Q. suber*) are prevalent. Broadleaved trees account for about 50 % with the exception of the boreal area (less than 10 %). In addition to the four oak species mentioned above (maps of distribution in figure 1), there is about 10 other oak species, including *Q. pubescens* (west, center and south), *Q. cerris* (Italy and Balkans), *Q. frainetto* (Iberian, south Italy, Balkans). Another important Fagaceae species is sweet chestnut (*Castanea sativa*) (in the Mediterraneans and west France).

Management of oak forest

The European oak forest has regularly been managed by the foresters since a long time. It is especially the case for the pedunculate and sessile oaks which produce very high quality timbers at 150-200 year old (1 cubic meter = 600 EURO = 500 $; 100,000 $ per hectare). Other oak species are less frequently intensively managed but they are very important for landscape and environment. Cork oak is specifically cultivated for cork production.

Oak diseases

Not speaking of insect defoliations which could be very damaging, in some ye ars oaks my suffer much from oak mildew. The fungus (*Microsphaera alphitoides*) invaded Europe in the beginning of the 20th century. Root rot fungi such as *Collybia fusipes* may also impair oaks in specific site conditions whereas comparatively Armillarias do not seem to be very important. A number of stem rots may also decrease the wood value (*Fistulina hepatica*, *Laetiporus sulfureus*, etc). In the Mediterraneans, oaks may suffer much from *Biscognauxia mediterranea*, a secondary parasite.

Oak decline

Decline of mature oaks was described in Europe a long time ago (Delatour, 1983 ; figure 2). It occurred repeatedly during different periods, and in different places. It has been a big concern to foresters especially when and where many oaks declined and died with in a few years in a forest. Another situation is when oaks dispay chronical crown deterioration even if few trees die. That situation is presently quite frequent in Europe in mature oak forest, as it can be seen through the European monitoring program started in 1986 (Eichhorn and Paar, 2000).

'Oak decline' is a disputed concept. Indeed, many very different detrimental factors are frequently present in the declining forests. The symptoms of decline are very general and non -specific and do not point to specific causes. They basically consist in progressive dieback of twigs and branches. Associated or additional symptoms can also be present such as occurrence of epicormic shoots, leaf clusters, reduced size and possible yellowing of leaves.

In the eighties a severe oak decline that occurred on mature trees in the high forest of Tronçais (center of France) was analyzed. Pedunculate oak died back, but not sessile oak, even when the two species were mixed in stands. Decline and mortality developed most severely on the poorest and more acid soils, and on waterlogged soils. In 1980, dendrochronological analyses showed that the severe drought that occurred in 1976 had reduced severely the radial growth of both oak species. The study showed that sessile oak recovered in growth earlier than pedunculate. Some pedunculate oaks did not recover in growth, having either very poor but even increments, or continuously decreasing poor increments. All pedunculate oaks wether they had recovered in growth or not displayed crown symptoms, while sessile oaks only displayed slight crown symptoms. Pathologists showed that on non-waterlogged soils, oaks which growth did not recover suffered from severe root rot by *Collybia fusipes*. In total (Lévy *et al.*, 1994), it was concluded that the 'crash' of Pedunculate in Tronçais, induced by a drought with the help of Collybia in some places, resulted from its presence in unproper sites in the forest where it had been artificially favored by man more than a 100 years before ('Ecological verdict '; Becker and Lévy, 1982). The 'Tronçais scenario' was considered quite general and valid for many forests, at least in France where Pedunculate oak is frequently grown beyond its ecological optimum. It also illustrated that different factors could participate in decline of oaks. Afterwards, ecological and ecophysiological status of oaks, and *Collybia fusipes*, were studied more intensively in France.

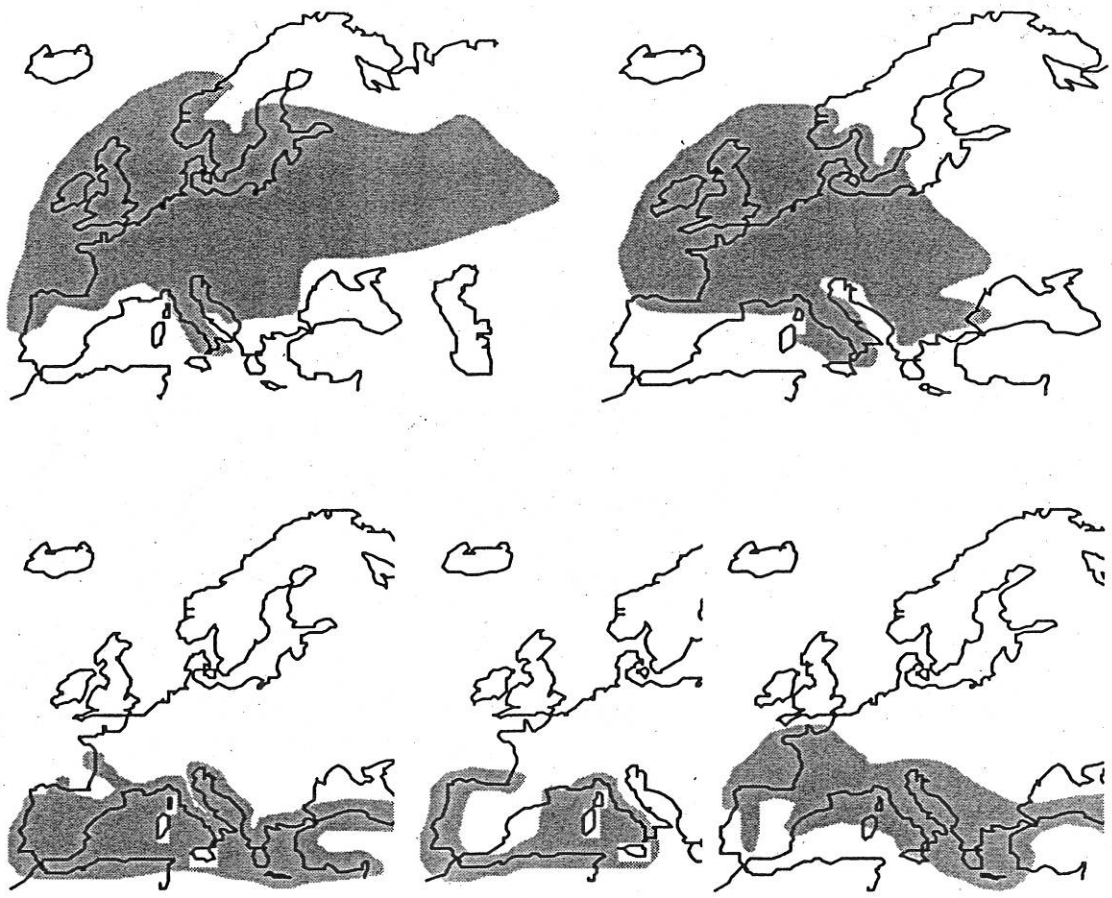


Figure 1 – Distribution of four oak species and of chestnut in Europe (according to Becker *et al.*, 1982)

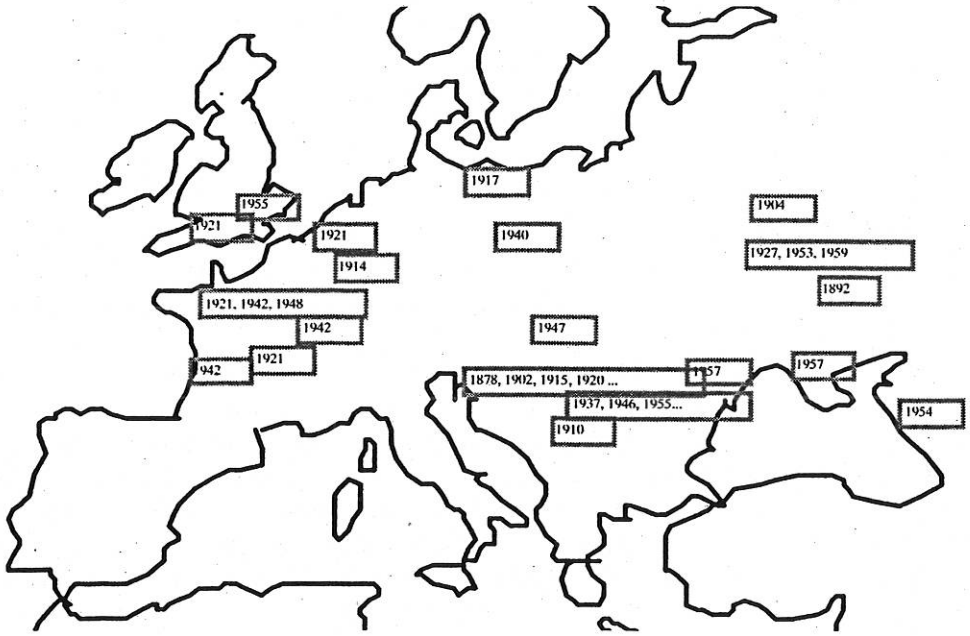


Figure 2- Occurrence of decline episodes of Pedunculate and Sessile oaks throughout Europe until the 1960's (according to Delatour, 1983)

Phytophthoras – background

The only damaging *Phytophthora* disease in forest known in Europe for a long time is the ink disease of chestnut due to *Phytophthora cinnamomi* or *P. cambivora* (Grente, 1961). It killed many trees in the Mediterranean's since 1900. A similar disease on the American red oak (*Quercus rubra*) due to *P. cinnamomi* was described in south-west France (Barriety *et al.*, 1951). It consists in a very damaging stem bark canker growing upwards to several meters of height. No decline or death of trees is associated with the disease. Other oak species c an be also infected. Many works were conducted on that disease of red oak in France in the last decade (Robin *et al.*, 2001).

Two events further stimulated European research on relation between Phytophthoras and decline of oaks, as mentionned by Brasier (2 000) :

Phytophthora cinnamomi and evergreen oaks in Iberia. Cork oak decline is known in Portugal for many years. However, an unusual intensive decline and mortality occurred in the period 1990 -92 in Portugal and Spain, in association with a unusual serie s of dry years. *P. cinnamomi* was associated with that decline (Brasier, 1992 ; Brasier *et al.*, 1993). A European research project ('Phyode') studied that question in 1995 -1997.

Phytophthoras and deciduous oaks in central western Europe. In Germany, Blasch ke (1994) hypothesized the involvement of *Phytophthora spp.* in oak root damage, based on histopathological evidence. Subsequent work (Jung *et al.*, 1996) showed that a number of Phytophthoras, including the new species *P. quercina* (Jung *et al.*, 1999) are present in the soil of oak forest, in association with decline of mature trees.

A European research project ('Pathoak') was launched in 1998. It aimed at better understand the role of Phytophthoras in oak decline in France, south UK, Germany and Italy. The m ain results obtained are presented thereafter with some others obtained elsewhere.

Are Phytophthoras present in the soil of oak forest ?

More than 150 sites were investigated throughout Europe (table 1). Basically, detection of Phytophthoras in soil at the base of oak trees was attempted by flooding soil samples in water, and using tender young leaves of pedunculate oak as baits.

Phytophthoras were detected in the soil of about half the sites investigated (table 1). Eleven species were detected (includi ng 3 new species : *P. europaea*, *P. psychrophila* and *P. uliginosa* [Jung *et al.*, 2001]), while some isolates remained 'unidentified'. *P. quercina* and *P. citricola* were the most frequent species (table 2). Different species of *Phytophthora* were often detected in individual sites, or below individual trees, in some cases abundantly (Hansen and Delatour, 1999). When sites were sampled repeatedly, the response was inconsistent with different *Phytophthora* species present in the different samplings. Provided that t his not simply link to limits in the methodology, this suggested fluctuation in the *Phytophthora* populations over time.

Phytophthoras were detected in a wide range of ecological situations but sandy soils were usually negative and heavy soils were positive (Jung *et al.*, 2000b). However, in the most acid soils Phytophthoras were absent or at least infrequent (figure 3). Below a pH (H2O) value of about 4 no Phytophthora was isolated. As a rule, Phytophthoras seem to be widespread on a large geographical area and no clear distribution limit could be detected at present. The only exception is with *P. cinnamomi* which is typically located in the south and west of Europe (figure 4).

It is worth to note that no stem bark symptom were observed in the investigated f orests, with the exception of cases associated with *P. cinnamomi*, or occasionally with other determined species (*P. citricola* or others).

Table 1- Frequency of oak forest sites with Phytophthoras present in the soil

ref. Country	Number of sites		Positive
	total	with Phytos	sites (%)
Jung et al., (1) 2000b ; (2) 1996			
Germany (1)	35	19	54
Switzerland (2)	1	1	-
Slovenia (2)	1	1	-
Hungary (2)	3	3	-
Italy (2)	4	4	-
Pathoak, 2001			
France	60	30	50
Great-Britain	17	9	53
Italy	30	19	63
TOTAL	151	86	57

Table 2- The Phytophthora species detected in the soil of oak forest (no. of forest sites)

ref.	Country	positive sites	Phytophthora species										
			quercina	citricola	cambivora	gonapodyides	syringae	cinnamomi	europaea	cactorum	megasperma	psychrophila	cryptogea
Jung et al., (1) 2000b ; (2) 1996													
	Germany (1)	19	18	7	7	3	3		1	2	1	2	
	Switzerland (2)	1		1									
	Slovenia (2)	1								1			
	Hungary (2)	3	1	2									
	Italy (2)	4	3	1						1			
Pathoak, 2001													
	France	30	13	11	3	6	6	5	8		5	1	
	Great-Britain	9	5	3	2	4							
	Italy	19	6	10	4	2	2	5		4	1		1
TOTAL		86	46	35	16	15	11	10	9	8	7	3	1
Frequency in 86 sites (%)			***53***	***41***	***19***	***17***	***13***	***12***	***10***	***9***	***8***	***3***	***1***

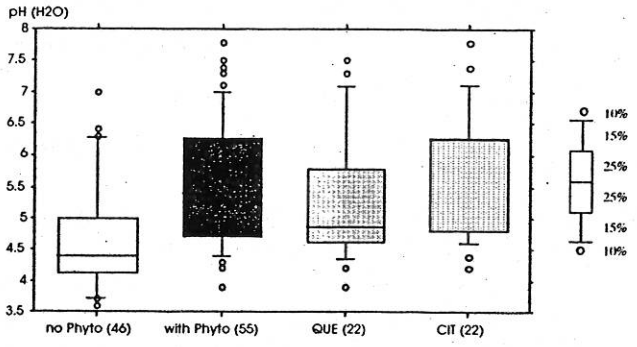


Figure 3- Distribution of the forest sites with or without Phytophthoras according to the soil pH (number of sites in brackets) (Pathoak, 2001).

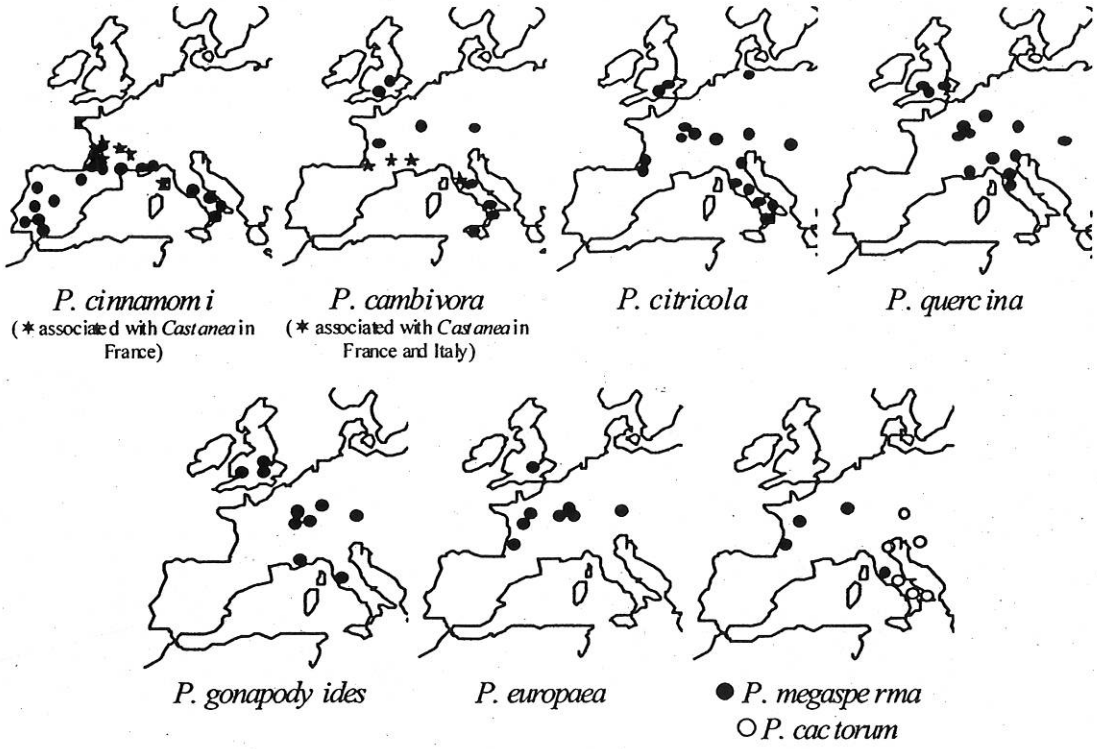


Figure 4- Distribution of Phytophthoras in oak forest in Europe. (Compiled from : Pathoak final report, 2001 ; Morel *et al.*, 2001 ; Lévy, 2000; Vettraino *et al.*, 2000 ; Robin *et al.*, 1998 ; Jung *et al.*, 1996 ; Phyode 2nd report, 1995 ; Brasier, 1992).

Pathogenicity of Phytophthoras

Damage to fine roots was assessed in several soil infestation experiments performed in different laboratories. All experiments included *Quercus robur* seedlings (2 y.o.); substrate was basically composed of a peat-sand mixture. Inoculum was added to the substrate as millet seeds infected in the laboratory. One to 6 floodings were applied depending on the experiments which lasted 3 or 4 months. Root damage was assessed visually or by measuring different root parameters (dry weight, number and length of roots, number of tips, and combination of that parameters ; most of them are detailed in Jung *et al.*, 2000a, b).

Mortality occurred in none of the experiments and the seedlings grew quite well in general whatever the amount of root damage. As compared to the controls, roots were most often reduced in the seedlings in presence of the *Phytophthora* species tested. Results were quite variable between the experiments but the *Phytophthora* species were globally different in pathogenicity as summarized in figure 5 for *Quercus robur*. As expected, *P. cambivora* and *P. cinnamomi* induced the highest root reduction. Similar root reduction were also produced by *P. quercina* and *P. citricola*. The other *Phytophthora* species seemed to be less or only occasionally damaging. In addition to the fine root reduction, bark lesions were observed on thicker roots and taproots associated with *P. cinnamomi* and, occasionally with *P. quercina* (Delatour *et al.*, 2000).

Other experiments using bark inoculation on the stem of seedlings or on logs showed that *P. cambivora* and *P. cinnamomi* were the most aggressive species to bark, *P. citricola* was moderately aggressive, while *P. quercina* not aggressive to bark (Brasier and Kirk, 2001 ; Pathoak, 2001).

No major difference in susceptibility was detected between the oak species tested, including *Quercus rubra*, with the exception of *Q. ilex* which was the most susceptible to the aggressive phytophthoras. That result is in accordance with other results showing that *Q. ilex* is more susceptible to *P. cinnamomi* than *Q. suber* (Tuset *et al.*, 1996 ; Robin *et al.*, 1998). However, it is important to note that the susceptibility of oaks to *P. cinnamomi* was much lower than that of *Castanea sativa* (Robin *et al.*, 1998) (see also table 4).

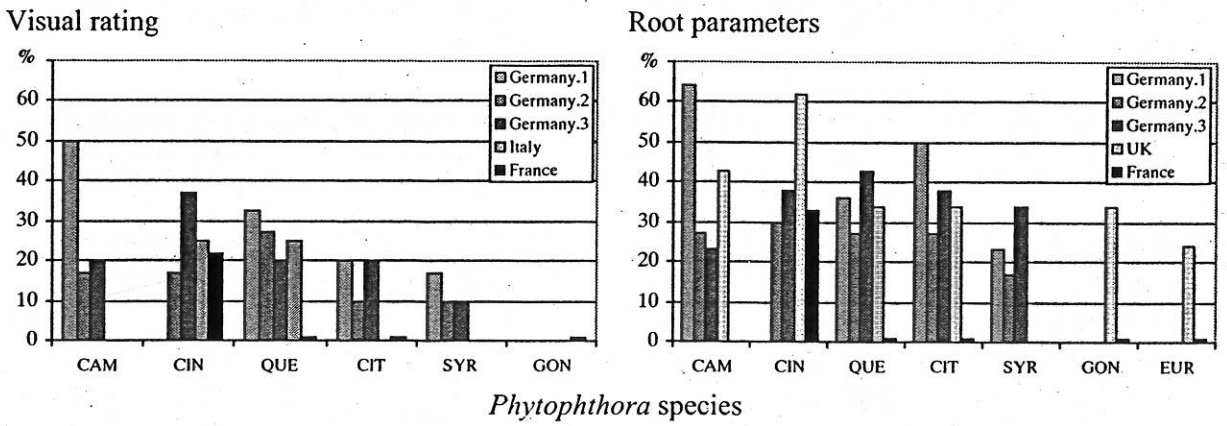
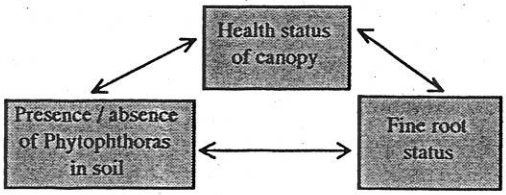


Figure 5- Root loss in *Quercus robur* seedlings in the presence of Phytophthoras in soil (% of the control ; mean values estimated from several experiments assessed in different ways ; compiled from Pathoak, 2001).

Are Phytophthoras associated with crown symptoms and root damage of oaks in forest ?

Three types of relation were considered.



Health status of canopy was assessed visually as the percentage of defoliation, according to the European system (anonymous, 1997). Trees rated below or above 25% defoliation were classified healthy or declining, respectively. Fine root status was assessed on the roots present in soil samples collected around each tree in a distance of 40 -150 cm from the stem base, up to about 20 cm deep. Only roots less than 5 mm in diameter were considered. Fine roots (less th an 2 mm diam.) were quantified according to Jung *et al.* (2000a,b).

Relation between health of canopy and presence of Phytophthoras in soil

When considering together all the *Phytophthora* species, no general relation was found between their presence in the soil below individual oaks and the health status of trees. In Bavaria, however, Phytophthoras were significantly more frequently detected below declining oaks than below healthy oaks (figure 6a), and the relative risk was higher than in other countries (t able 3).

When considering *P. quercina* in the only stands where that species was present, a significant relation was found in Bavaria (figure 6b), and crown status was correlated with the occurrence of *P. quercina* in the rhizosphere (Jung *et al.*, 2000b). A similar tendency was suggested in east France (figure 6b). Otherwise in France, no relation was found for *P. citricola* (121 oaks in 11 stands), *P. europaea* (106 oaks in 8 stands) and *P. syringae* (112 oaks in 6 stands), respectively.

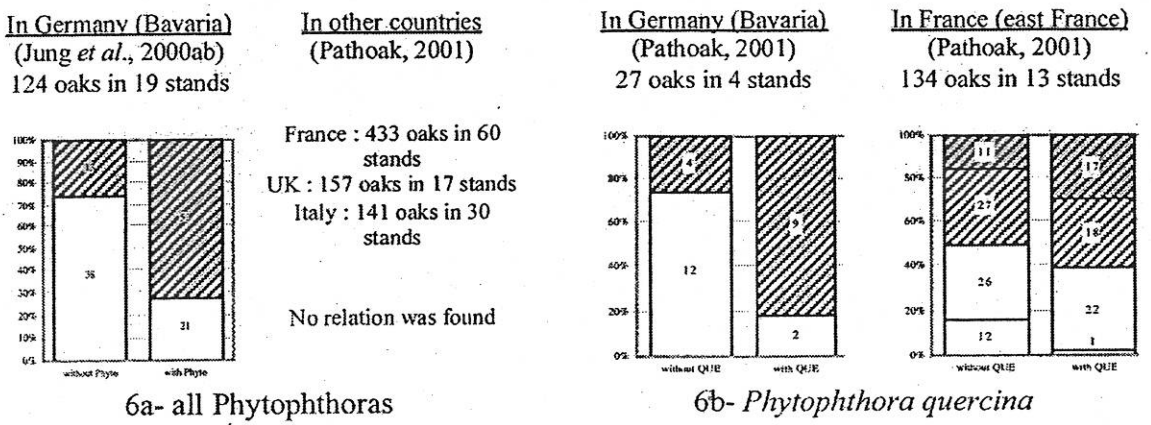


Figure 6- Distribution of the healthy (□) and declining (■) oaks according to the presence of Phytophthoras in the soil below

Table 3- Relative risk of Phytophthora to be detected below a declining oak, as compared to a healthy oak (Jung *et al.*, 2000b for Bavaria; Pathoak 2001 for Italy and France).

Phytophthoras	country	risk
all together	Bavaria	2.8
P. quercina	Bavaria	2.1
	Italy	1.5
	France	1.2
P. citricola		
P. europaea	France	c.a. 1
P. syringae		

Fine root status of declining oaks

In the stands without Phytophthoras present in the soil, only investigated in Germany, declining and healthy oaks were not significantly different for fine root status (figure 7).

In Germany (Bavaria), in the stands where Phytophthoras were present fine root status of declining oaks was consistently poorer than that of healthy oaks (Jung *et al.*, 2000ab; figure 7). In France and in Italy, results tended to be similar , but with erratic differences between declining and healthy trees in some stands (Pathoak, 2001).

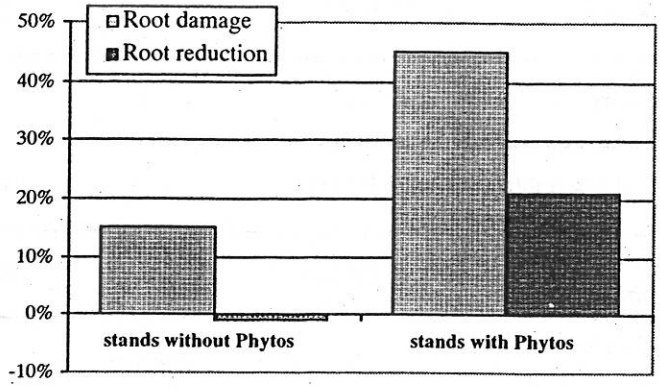


Figure 7- Fine root status of declining oaks in Bavaria, Germany, in stands infested or not infested with Phytophthoras. [Compiled from Jung *et al.*, 2000ab. Relative values as compared to the healthy trees (19 stands with Phytophthoras and 16 stands without ; 59 healthy and 65 declining oaks, and 47 healthy and 46 declinin g oaks, respectively) ; 'root damage' was assessed visually ; 'root reduction' is the average value of the 4 root parameters measured by the authors]

Fine root status of oaks with or without Phytophthoras

In the stands with Phytophthoras present, fine ro ot status was also poorer in oaks with Phythophthoras than in those without, in Germany (Jung *et al.*, 2000ab) and in Italy (Pathoak, 2001). In France, however, no consistent difference was detected when considering the situation of Pedunculate oaks with *P. quercina*, *P. syringae* or *P. cinnamomi*, respectively (Pathoak, 2001).

In total for fine roots, it was clear that in many occasions presence of Phytophthoras in the soil of a stand, or below individual trees, was associated with a reduced amount of roots.

How damaging is root reduction to oak health ?

That question was examined experimentally on seedlings (3 y.o.) in pots with *P. cinnamomi* added to the substrate. Several parameters, as shown in table 3, were monitored during 1 year of infection. In addition to oak species, sweet chestnut and hybrid chestnut (*Castanea crenata X C. sativa*) were included in the experiment as highly susceptible and resistant species, respectively.

Results showed that the low susceptible oak species (pedunculate and red oaks) did not suffer significantly from root infection, as compared to the high susceptible one (holm oak) in which several plant parameters were impaired, even if no seedling mortality did occur (table 4).

Table 4- Effect of root infection by *Phytophthora cinnamomi* on oak and chestnut saplings Pathoak, 2001).

	Resistant → Susceptible			
	Hybrid chestnut	Pedunculate oak and Red oak	Holm oak	Sweet chestnut
Root loss (biomass)	c.a. 0%	34-36%	64%	100%
Predawn leaf water potential		not affected	reduced	
Leaf nutrient content		not affected	decrease in N and P	
Biomass partitioning		not affected	increase in leaf mass ratio	
Mortality	none	none	no mortality at 70% of root loss	up to 100%

Conclusion

The general concept of "Oak decline" does not correspond to a unique phenomenon. Indeed, in some stands decline consists in a quick death of many trees which deve lops within a few years. In others, decline is chronic and develops over many years or decades ; death of the defective trees does not always occur. In a number of so-called cases of "oak decline", caterpillar defoliation or unusually severe droughts are c learly a major cause. Especially for drought, decline severity is also strongly modulated by other factors, such as soil conditions, and does not occur similarly on different oak species.

Not presented in the present paper, recent results obtained during the Pathoak project by carbon balance simulation showed that tree dynamics, then death, are paralleled by decreases in stored and remobilised carbon ; declining trees suffered a large imbalance in carbon, and the hypothesis put forward is that tree death occurs once stored carbon decreases below the cost of new early wood and leaf construction during spring. Otherwise, the Water Use Efficiency was lower in *Q. robur* than in *Q. petraea*, showing their different ecological behaviour (Pathoak, 2001).

For a pathologist, it is important to be aware of pathogens are only one out of the many factors that may impair the oak ecosystem. That way, he tries to know to which extent pathogens are involved in specific cases of oak decline, in association with other factors.

An example of a root pathogen involved in the long lasting process of decline of oaks, in interaction with site conditions, is with the root rot fungus *Collybia fusipes*. In France, works of Marçais and colleagues showed that the parasite is widespread in oak ecosystems where it may be responsible of severe reduction of root system. It became clear that severity of infection and the subsequent impact on tree health, including final death, strongly depends on the local conditions in which the oaks are grown, and the Collybia-associated-oak-decline occurs mainly on *Q. robur*

grown on sandy and well drained soils (Marçais *et al.*, 2000 ; Piou *et al.*, 2001 ; Camy and Marçais, 2001).

Another example of interaction is with the littleleaf disease of shortleaf pine (*Pinus echinata*) in the southern United States as summarized by Hansen (2000). The disease developed in a context of nutrient deficiency on eroded soils with poor internal drainage where stressed trees were unable to efficiently replace rootlets which mort ality was incited by *P. cinnamomi*.

Coming back to Phytophthoras on oaks in Europe, what is now the situation with the recent findings ?

As several species of *Phytophthora* are widespread in European oak forests and, in many cases without any serious oak decline, it is difficult to consider they are a general threat to all forests. However, the situation of some particular species must be examined more specifically.

The introduced species *P. cinnamomi* and *P. cambivora* were detected in oak forest. Their pathogenicity to oak roots and bark was confirmed. Interestingly, *P. cinnamomi* is distributed only in the parts of Europe where frost does not limit its developpement (Marçais *et al.*, 2000). There is many arguments for its involvement in the recent decline an d death of the evergreen oak species in the Iberian countries, and in some places in France. *P. cambivora* is present in a larger area. No evidence of decline of oaks was obtained in association with *P. cambivora* ; however that species is most often associa ted with chestnut decline in Italy (Vettraino *et al.*, 2000).

Among all the Phytophthoras, *P. quercina* and *P. citricola* were the species most frequently detected in a large part of Europe, and *P. quercina* is specific to oaks (Jung *et al.*, 2000b). Both are fairly pathogenic to fine roots of oaks, but *P. quercina* is not pathogenic to stem and root secondary bark. There is several evidence of an association in oak forest between presence of *P. quercina*, or of Phytophthoras in general, and a deteriorated condit ion of fine roots and of tree canopy. That type of association, and the distribution of *P. quercina* over a large part of Europe, focuses the attention on that species more specifically. However, evidence obtained in forest conditions cannot be interpreted directly as cause-effect relationships, and many questions remain!

It is difficult to know what amount of root reduction an oak may suffer before a significant impact on tree health occurs. Seedlings may bear considerable root loss without a major impact occurs on their development. Root loss in mature oak trees must be examined differently as effects are cumulative over many years. However, we poorly understand how works in forest the fine root compartment in the presence of the microbial soil borne partn ers, *Phytophthora* species, and other fungi including mycorrhyzal species.

It would be particularly important to know how parasites contribute to the fine root turnover and to determine at which level a turnover becomes detrimental for an oak in a given e nvironmental condition. Another lack of information is the situation of the deep root system of oaks. In the case of *P. cinnamomi* on Eucalyptus, it was shown that damage to the vertical roots are important to consider to understand the behaviour of trees e specially in relation with their reaction under drought conditions (Shea *et al.*, 1983). *P. cinnamomi* and *P. cambivora* are able to produce root bark damage. Accordingly, those species could potentially be more harmful to trees than the species able to destroy only fine roots, such as *P. quercina*. Finally, we don't know what is more important for a tree between (i) chronical destruction of fine roots and increase of turnover which would concern management of tree reserves, and (ii) sudden destruction of large part of the root system during population blooms which would concern transportation of nutrients and water.

The studied *Phytophthora* species did not appear to be able to threaten drastically health of oaks by their own, without involvement of other factors. They have no role in the very frequent oak declines located on acid and waterlogged soil because they are not present in those sites. On the opposite in south west France, the American red oak which root susceptibility to *P. cinnamomi* is similar to that of pedunculate oak, does not decline in the severely infected sites.

Water relations were investigated on oak seedlings inoculated with *P. cinnamomi*. Despite effects induced by the root infection resembled those of water stress, limitations of water losses in leaves allowed infected trees to survive to important root losses, even in susceptible host species. In forest however, because of their reduced capacity to prospect the soil and to extract water, infected adult trees would be more vulnerable to drought. Such a Phytophthora impact was probably illustrated by the cork oak and holm oak decline and mortality that occurred in Iberia in relation with severe droughts in the 80's (Brasier, 2000).

Climate change and anthropogenic nitrogen input are another concern, as discussed by Jung *et al.* (2000a). Any change in oak ecosystems could change the host-parasite balance, and even more in the case of Phytophthoras which produce infectious propagules very rapidly.

It is difficult to forecast the balance between the positive and the negative effects of anthropogenic nitrogen input into forest soils. Experiments suggested that different *Phytophthora* species could react differently to nitrogen supply. Large difference could also exist between sites or parts of Europe. Nitrogen emission varies from more than 100 kg per hectar in south Germany to less than 40 kg/ha in most parts of France (EMEP, 1998).

Forecasting is also difficult for climate change. The only documented effect is for *P. cinnamomi*. With rising temperature a potential enlargement to the north of its range of distribution is predicted in Europe (Brasier, 1996). Effects of climate change which could include the rise of winter temperature and a seasonal shift of precipitation from summer to winter are only hypothetical at present.

Whether introduced or autochtonous, the Phytophthoras present in the soil of oak forest may bring a selective pressure on oak ecosystems, especially in reducing the amount of fine roots. In that way, they may contribute to a long lasting process of health decrease or decline of oaks. However, it is difficult to draw a general picture for Europe where oak forest is very diverse in many respects : oak species present, ecological situations, history of the stands and sylviculture, etc. Moreover, Phytophthoras are not the only factors involved and the selective pressure must be considered more globally as many other parasites, or other factors, interact and overlap with activity of Phytophthoras and with tree health. In many oak stands, trees are quite old, more than 150 or 200 years, and derive from coppice with standard stands transformed gradually in high forest. In Europe, no oak forest can be considered as a genuine natural forest.

In the case of the *Phytophthora* species involved in fine root reduction, but harmless to main roots or stem bark, we can consider that they may contribute to the oak decline process in certain circumstances. Accordingly, foresters cannot further consider that oaks are resistant to everything. They will have to grow and manage the different oak species more accurately than before, taking into account their respective ecological requirements and the local site potentialities. That way, oak forest in Europe will be in a better condition to challenge the coming environmental changes, and hopefully many occasions of oak decline will be avoided.

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PANEL: SWISS NEEDLE CAST – WHAT WE DIDN'T KNOW

Moderator: Jeff Stone, Oregon State University, Corvallis

Effect of Climate on Infection Biology and Epidemiology of *Phaeocryptopus gaeumannii* and Swiss Needle Cast

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Abstract

Disease severity varies between sites affected by Swiss n eedle cast in the Oregon Coast Range, but within sites measures of severity have remained at similar levels over four years. Severity of disease appears not to be increasing in affected coastal Oregon sites, but in sites with severe disease it is not diminishing. Levels of *P. gaeumannii* are negatively correlated with needle retention. Disease severity is influenced by site specific factors that favor pathogen growth. Climatic factors that favor fungal infection and colonization are strongly correlated wi th disease severity measures. Environmental parameters that correlate well with pathogen growth and disease severity are winter degree day accumulation and spring/summer leaf wetness at 14 -16 C.

Introduction

Despite periodic interest in the disease, th ere has been little documentation of the distribution, severity, and growth impacts of Swiss needle cast in forests in the Pacific Northwest. Most of the published research on Swiss needle cast disease comes from Christmas tree plantations or forests in Europe or New Zealand where Douglas-fir is planted as an exotic species (Boyce 1940, Chastagner 1996, Hood, 1996, Hood and Kershaw 1975). Severe defoliation and growth reduction due to Swiss needle cast disease were observed in Douglas -fir plantations in Switzerland as early as 1925 (Gaeumann 1930) and subsequently reported from other European countries and eastern United States (Boyce 1940), New Zealand, and Australia (Beekhuis 1978, Hood 1996). However, factors affecting the distribution and severity of the disease in the forests of the Pacific Northwest where both Douglas-fir and the pathogen are native have received little attention. In contrast to the situation in Europe and other areas where Douglas -fir is cultivated, defoliation due to Swiss needle cast has not been documented in forests of the Pacific Northwest until recently (Hansen et al 2000).

Phaeocryptopus gaeumannii, the causal agent, is widespread in the Pacific Northwest, but until recently was considered insignificant in North American forest situations (Boyce 1940, Hood 1982). Although recent concern about Swiss needle cast near Tillamook dates from 1990 or later, there were earlier observations of the disease in the vicinity, and it is almost certain that the fungus is native to the area. Meinicke (unpublished, cited in Boyce 1940) collected the fungus in 1938 near Otis Junction and Hebo near the center of the current area of severe symptoms, but stated that it was not causing defoliation or yellowing. In comparing the effect of *P. gaeumannii* on its host in the Northwestern U.S. to that in Europe and the eastern U.S., Boyce (1940) stated:

"Within the natural range of Douglas-fir in western North America the fungus has been present for many years, although it passed unnoticed...because there the fungus is either not at all or so negligibly injurious to the host that it is easily overlooked." and later "In the Douglas -fir region of the Pacific Coast, even though the fungus is prevalent, it has caused no injury." The amount of foliage discoloration, defoliation, and growth loss observed in Douglas -fir in the Oregon Coast Range due to Swiss needle cast in recent years indicates an intensification of the disease since Boyce's observations.

The possible reasons for the widely different effects of infection by *P. gaeumannii* on Douglas-fir in Europe compared to that in the western U.S. were considered by Boyce (1940), and similarly the possible causes of the apparent intensification of effects of Swiss needle cast disease in the coastal region since Boyce concern us now. Boyce (1940) proposed four possibilities to account for differences in effects of *P. gaeumannii* in Europe and the Pacific Northwest, and these same possibilities also have been investigated with respect to the recent epidemic. Possible causes proposed by Boyce were: 1) A new pathogenic strain of fungus, a derivative of a weak parasite or a hybrid strain; 2) A novel strain or species introduced into Europe and eastern U.S. from Asia; 3) *P. gaeumannii* is really *P. nudus* that jumped a new host; 4) *P. gaeumannii* is a nearly harmless parasite native to the western U.S. and Canada, introduced into Europe and eastern N. America where it is more pathogenic due to climatic conditions more favorable to the development of the fungus. Of these possible explanations, Boyce favored the latter: "Hence it seems not unreasonable to assume that *Adelopus gäumannii* has changed from a harmless parasite on the Pacific Coast to a pathogen in the different climates of the northeastern United States and Europe."

Boyce's hypothesis that a climate more favorable for growth of *P. gaeumannii* primarily accounts for the SNC epidemic in Europe is the most widely accepted explanation for differences in disease severity between Europe and western North America, although specific contributory climate factors have not been identified. Similarly, climate factors may be important factors in the current SNC epidemic in Oregon. Higher than historically normal levels of *P. gaeumannii* may have developed in areas of coastal Oregon due to recent climate change, short term variations in weather patterns influenced by ocean currents, or increases in acreage of Douglas -fir plantations in locations with climate conditions particularly favorable to the development of the fungus. We have been monitoring several measures of fungal colonization and disease severity in relation to environmental and site factors to attempt to identify site climate characteristics that might be useful for prediction of disease risk and understanding environmental factors influencing pathogen growth and development. The objectives of this research are to determine whether the epidemic of Swiss needle cast in Oregon is intensifying, to identify environmental factors that correlate with measures of fungal colonization and disease severity, and to understand how growth of the pathogen is influenced by climate.

Materials and Methods

Measurements of disease impact were made at nine monitoring plots first established in 1996. The nine plots were grouped in three clusters of three plots each in the vicinity of Tillamook, Oregon (Table 1). The plots in each cluster were established in Douglas -fir plantations of the same age and where possible the same seed source. Plantations were selected to represent different elevations and distances from the ocean, and exhibited a range of disease severity. One plot in each group has moderate to heavy symptoms of Swiss needle cast and one site is classified as healthy.

The South Cluster of plots are all USDA Forest Service progeny test plantations. Ten trees of each of two families were selected for measurements in each plantation. Plots of the Tillamook Cluster were planted with seedlings from the same bulk seed lot, from the "Boundary" seed collection area of the Coast Ranges, at about 600 m elevation. Ten trees were randomly selected for measurements in each plantation. The North Cluster included one plot planted with the Boundary source (North Fork), and two Oregon Department of Forestry progeny test plantations. Ten trees of each of two families (different from the South plots) were selected for measurements in each of the latter plantations, and ten trees were measured at North Fork.

Table 1. Characteristics of field plots.

SITE	Disease Severity	Elevation	MILES TO OCEAN/BAY	AGE (1996)	SEED SOURCE	Aspect
JUNO HILL	Severe	380	2.25	14	Boundary 1800FT	NE
STONE RD LOWER	Mild	430	14.75	14	Boundary 1800FT	SW
STONE RD UPPER	Healthy	1700	14.5	14	Boundary 1800FT	N
N FORK	Severe	160	4.75	10	Boundary 1800FT	SW
COAL CRK PROGENY	Moderate	220	5	10	1600FT & 1400FT	SE
ACEY CRK PROGENY	Healthy	670	8	10	1600FT & 1400FT	E
SALAL PROGENY	Moderate	370	4	9	1000FT	NW
CEDAR NORTH PROGENY	Mild	1500	7.5	9	1000FT	NW
LIMESTONE PROGENY	Healthy	890	12.25	9	1000FT	N

Each study site was equipped with weather monitoring equipment. Electronic leaf wetness and temperature sensors (model 3601T or 3601TWD, Spectrum Technologies, Plainfield, IL) were maintained at each site. Symptoms of Swiss needle cast have been measured annually at all nine sites since 1998. Tree height and diameter were measured and a visual index of crown density, transparency, and discoloration was determined for each tree. Needle retention was determined for two lateral branches from the mid crown (fifth whorl below the terminal shoot), and foliage samples were collected for determination of infection incidence and severity for each tree. All measurements and foliage collection were done in the spring just prior to bud break.

For determination of infection incidence and severity, needles for each age class/tree were stripped from branches and combined. Fifty needles for each age class/tree were randomly selected and affixed to index cards with double faced adhesive tape. The needles on index cards were then examined under a dissecting microscope. Incidence of infection was recorded as the proportion of 50 needles bearing pseudothecia of *P. gaeumannii*. Severity, the number of stomata occluded by pseudothecia, was determined by counting pseudothecia on ten infected needles. Three sections, 2.6 mm x .26 mm, of each needle were counted with the aid of a dissecting

microscope. Another sample of ten randomly selected needle s from each age class/tree was used for quantitative PCR analysis (Winton et al in press).

Climate data summaries for each site were generated using Specware v. 5.0 (Spectrum Technologies, Plainfield, IL). Statistical analyses of differences in needle r etention, pseudothecial density, PCR value (normalized *P. gaeumannii* DNA) between sites were carried out by ANOVA with Fisher's LSD multiple comparisons procedures in SYSTAT 9.0. Correlations between needle retention, pseudothecial densities, PCR value, a nd leaf wetness were carried out with SYSTAT v. 9.0.

Results

Retention of two-year old needles is a good indicator of disease severity at the nine coastal sites. During the past four years, retention of two -year old needles has varied, but there is no consistent trend to suggest that needle retention at diseased sites is decreasing, or that SNC at healthy sites is intensifying (Figure 1). This is despite an incidence of SNC on one -year old foliage very close to 100% at all sites. Needle retention at the two most severely diseased sites, Juno Hill and North Fork, increased in 2001, possibly indicating a lessening o f disease severity. On average, the most severely diseased sites in each group (north, central, south) ha d the lowest retention of two-year old needles. (Figure 3). Foliage discoloration follow ed a similar pattern, with Juno Hill and North Fork showing the most severe symptoms (data not shown). Mean foliage discoloration over the past four years and mean retention of 2 year -old needles over the past four years were highly correlated (r=.95, p=0.00).

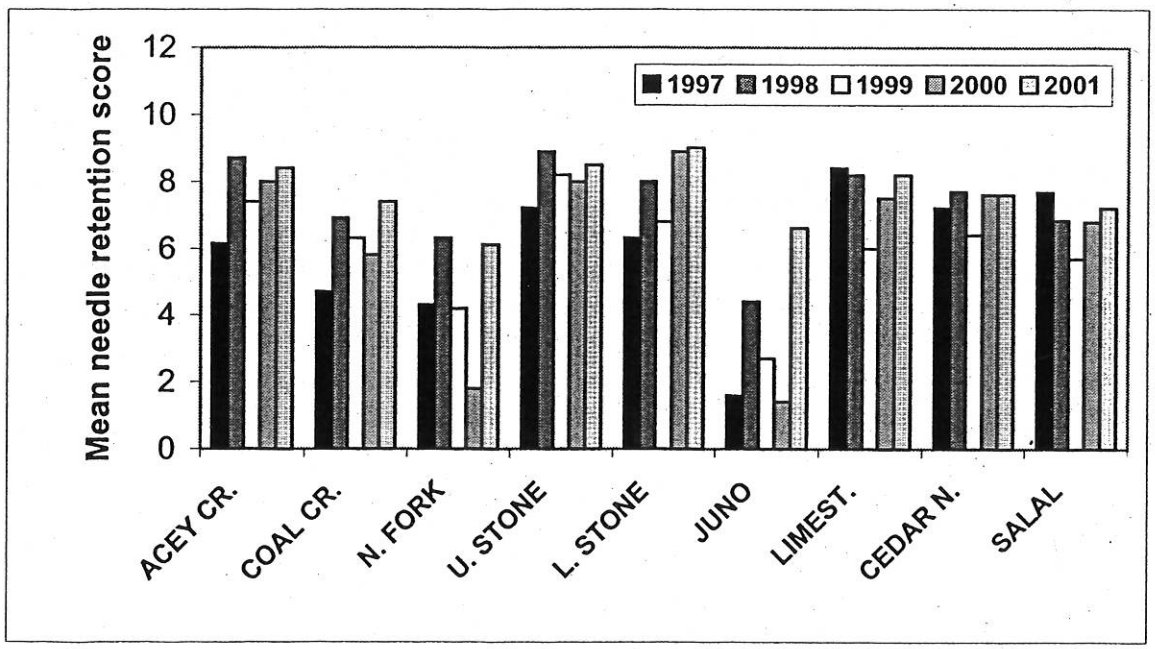

Figure 1. Yearly patterns of needle retention in nine coastal Oregon SNC study sites, 1997 -2001.

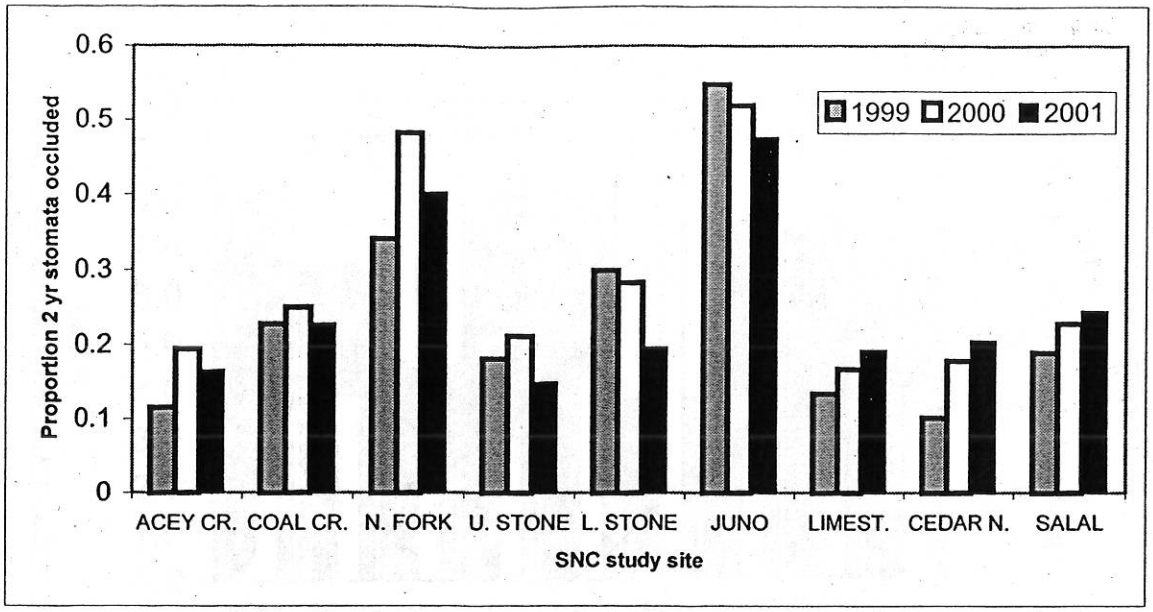

Figure 2. Abundance of pseudothecia on foliage for three years at nine coastal Oregon SNC study sites.

Number of pseudothecia on one- and two-year old needles (pseudothecial density) is an indication of the degree of fungal colonization of foliage. Although incidence approached 100% at all sites, pseudothecial densities on two year old needles varied among sites over the past three years, and like needle retention did not appear to be increasing or decreasing. Pseudothecial densities in 2001 were lower than the preceeding year for the north and middle groups of sites, but have been steadily increasing in the southern set of sites (Figure 2). Pseudothecial densities on two year old needles (1998 needles sampled in April 2000) for the two most severely diseased study sites, Juno Hill and North Fork, were statistically equivalent, but greater than all other sites at $p < 0.001$. Pseudothecial densities of one-year old needles (1999 needles sampled in April 2000) were also highest for Juno and North Fork, but were significantly different from each other. In general, density of pseudothecia on one-year old needles closely parallels the values for two-year old needles within each site (Figure 3). Pseudothecial densities on one and two year needles were very highly correlated (Pearson coefficient = 0.952, $p = 0.001$), as expected.

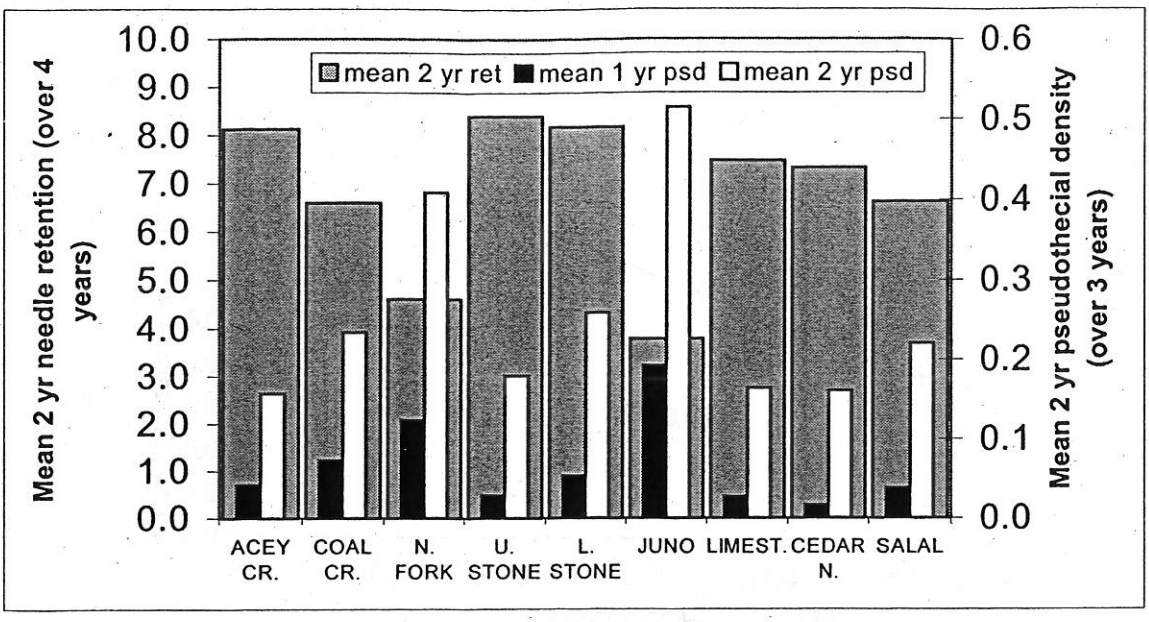

Figure 3. Mean needle retention over five years (1997 -2001 and pseudothecial density over three years (1999-2001) for nine coastal Oregon SNC study sites.

PCR analysis of one- and two-year old foliage (Table 2) agreed well with the pseudothecial density measurements (Pearson coefficient = 0.976, P<.000 for 1 year old needles and Pearson coefficient = .942, P< .001 for 2 year old needles measured in spring 2001). For two-year old foliage, the Juno site had the highest colonization levels detected by quantitative PCR, followed by North Fork and Salal in one statistical group, with the remaining six sites not statistically different.

Table 2. PCR analysis of foliage from nine coastal study sites. Letters following values in rows are not different at p<0.01. Results of spring 2000 and spring 2001 samples.

PCR	Acey	Coal Creek	North Fork	Upper Stone	Lower Stone	Juno	Lime-stone	Cedar	Salal
2000									
AC 98	.637 a	1.234 a	3.226 c	1.233 a	1.072 a	4.953 b	1.119 a	1.023 a	2.496 c
AC 99	.242 a	.541 a	1.785 c	.220 a	.609 ab	3.026 c	.316 a	.255 a	.978 b
2001									
AC 99	.666 c	.645 c	2.069 a	.983 b	.870 bc	2.707 a	.579 c	.567 c	1.200 b
AC 00	.131 c	.364 bc	.413 b	.139 c	.082 c	1.616 a	.076 c	.110 c	.258 bc

Pseudothecial density was inversely related to needle retention at the study sites (Figure 4). Retention of two-year old needles was highly correlated with pseudothecial densities on two - year old needles (Pearson coefficient = 0.912, P < .01), and with pseudothecial densities on one-year old needles (Pearson coefficient = 0.869, p < 0.05). Sites with the greatest numbers of pseudothecia on two-year-old needles, Juno Hill and North Fork, also have the most severe disease symptoms (Figs. 1, 2). Juno Hill, the most severely diseased site, has an average needle retention score of 3.8 (approximately 38% of the full complement), with pseudothecia occupying 51.5% of two-year old needles and 19.3% of one-year old needles. In contrast, sites with low or moderate disease such as Upper Stone and Acey Creek have retention of over 80% of second year

foliage, with about 15% of stomata occluded in two-year old needles and less than 5% for one-year old needles (Figure 3). Quantitative PCR values of SNC field study sites were also correlated with retention of two-year old needles (Figure 5).

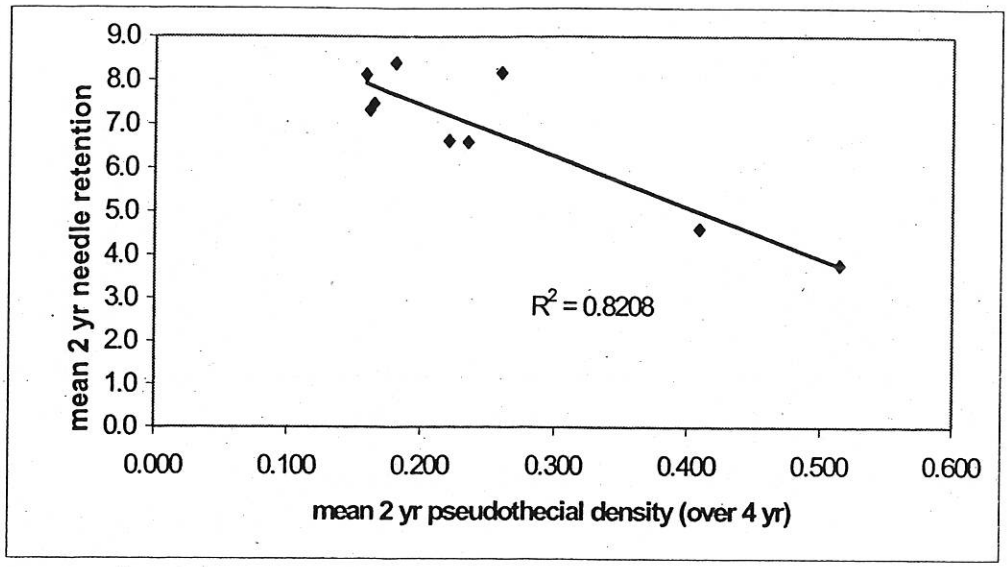

Figure 4. The relationship between retention of two year old foliage and pseudothecial density at nine coastal Oregon SNC study sites. Mean 2-year needle retention was averaged over four years.

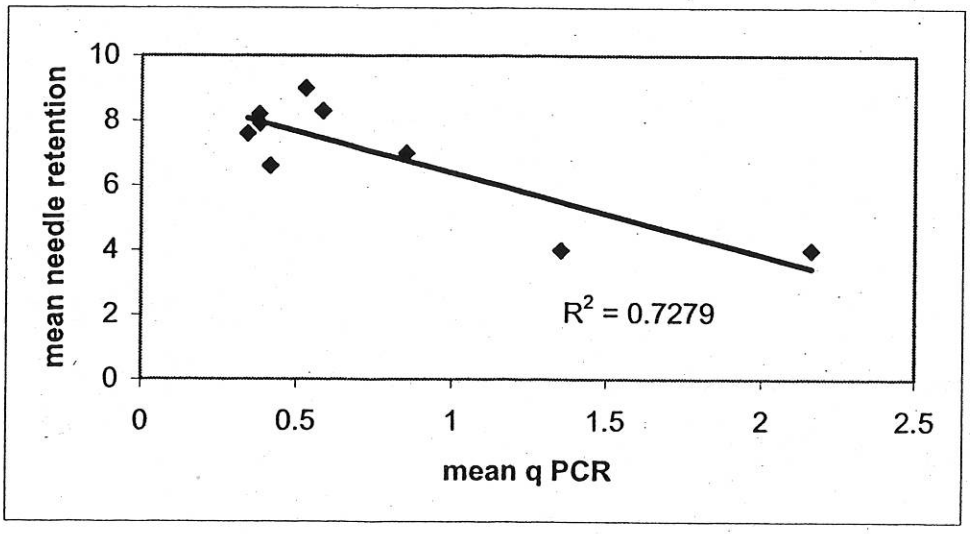

Figure 5. Relationship between colonization of foliage by *P. gaeumannii* and retention of two-year old needles. Amount of *P. gaeumannii* infoliage determined by quantitative PCR. Retention of two-year old needles was averaged over two years.

A strong correlation between pathogen colonization and needle retention was also supported by studies on potted seedlings. In potted seedlings that were exposed to varying levels of inoculum in May-June 1999 and then assessed for pseudothecial density and quantitative PCR

in the spring of 2000, and one-year-old needle retention in November, 2000, needle retention was strongly correlated with measures of pathogen colonization (Figures 6,7).

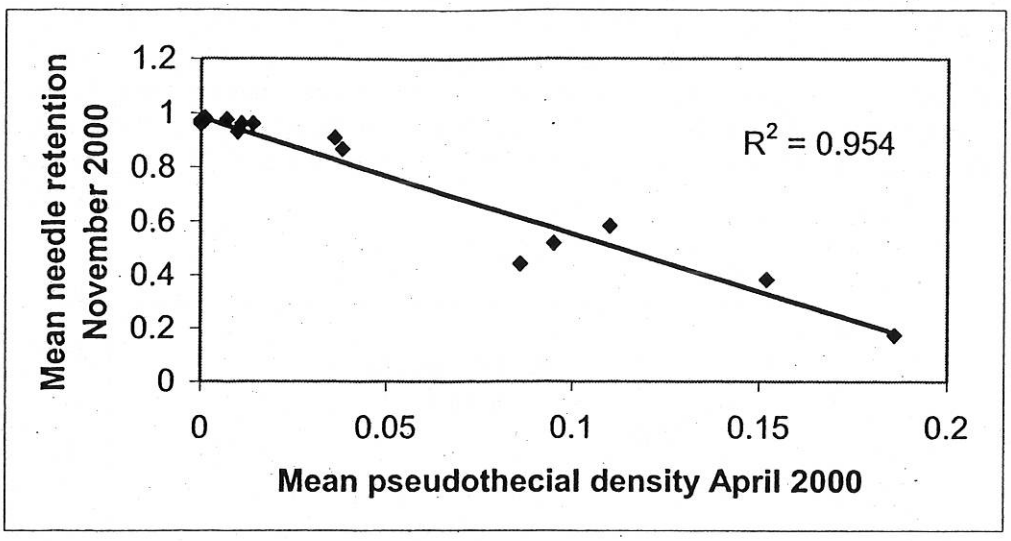

Figure 6. Relationship between pseudothecial density i n April 2000 and retention of one-year old needles in November 2000 for potted seedlings. Seedlings were exposed to inoculum at a diseased site for varying periods May -June 1999 and returned to the OSU Botany Field Lab for incubation.

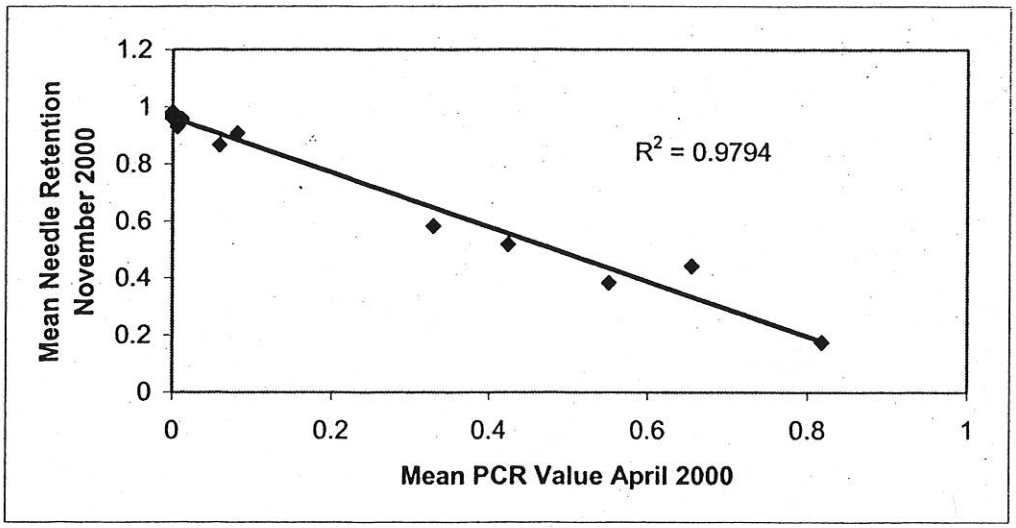

Figure 7. Relationship between *P. gaeumannii* biomass (QPCR) in April 2000 and retention of one-year old needles in November 2000. Seedlings were exposed to inoculum at a diseased site for varying periods May -June 1999 and returned to the OSU Botany Field Lab for incubation.

Because infection levels and disease severity within sites appear to have remained at relatively constant levels in recent years, and because infection levels remained similar within sites from year to year, environmental variables that differ across sites and that might affect fungal growth were investigated. Free surface moisture is necessary for infection by most foliar plant pathogens, and in general higher infection levels are associated with prolonged periods of free moisture. The optimal temperature range, and optimum period for fungal growth also should be considered. Several combinations of temperature range, threshold leaf wetness values, and season were tested for separation of sites by disease severity and pa thogen abundance. Two sets of parameters provided good correlations with amounts of fungal colonization at sites: leaf wetness hours at 14-16 C between May – Oct (Figure 8) and winter degree day accumulation 6 – 26 C (Figure 9).

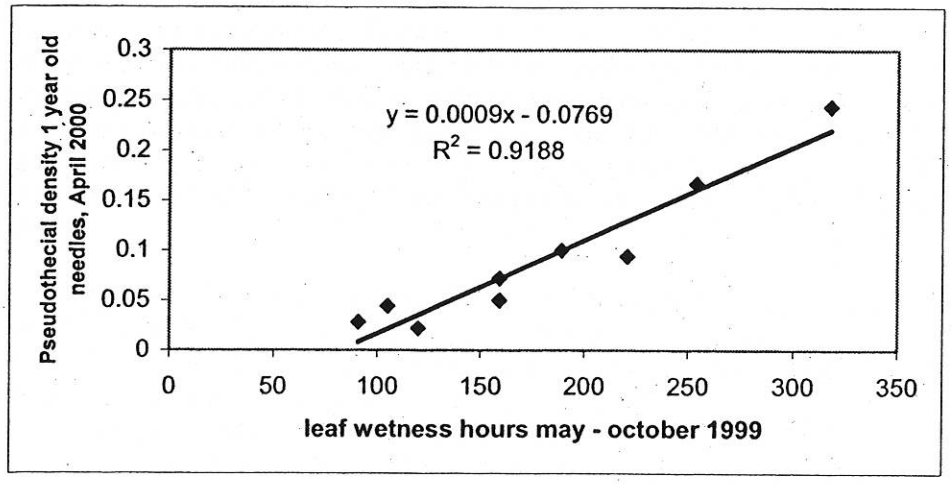

Figure 8. Relationship between cumulative leaf wetness at 14 – 16 C between May and October, 1999 and abundance of pseudothecia on one-year-old needles for nine coastal Oregon SNC study sites.

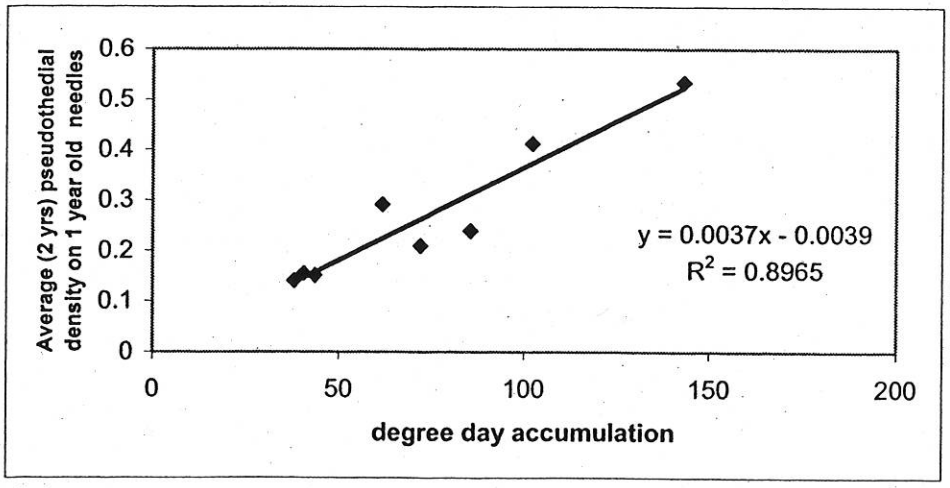

Figure 9. Relationship between cumulative winter (December – February) degree days at 6 – 26 C and abundance of pseudothecia on one-year-old needles for nine coastal Oregon SNC study sites.

Discussion

There is a strong correlation between levels of *Phaeocryptopus gaeumannii* and defoliation and discoloration of Douglas-fir in coastal plantations in Oregon. The number of pseudothecia on one- and two-year old foliage are highly correlated with total needle retention. Regardless of age, needles are abscised when more than approximat ely 50% of stomata are occupied by pseudothecia (Hansen et al. 2000), a consequence of impaired gas exchange (Manter et al 2000). Thus, on severely diseased sites a majority of two -year old needles may be lost due to high infection levels, but on sites wh ere inoculum levels or colonization rates are less, a majority of three- and four-year old needles may be retained. Hood (1990) also noted a relationship between increasing infection levels and loss of needles in older age classes in Douglas-fir plantations in New Zealand. Our evidence points to Swiss needle cast disease as the primary cause of needle loss, and not a secondary colonist of foliage weakened by another agent. Consistently greater needle retention in foliage sprayed with chlorothalonil indica tes the involvement of a fungal foliar pathogen in the defoliation of Douglas -fir trees on the Oregon coast. *Phaeocryptopus gaeumannii* is the only foliar pathogen present on the trees before treatment, and is the only pathogen that is abundant throughout the area of the epidemic (Hansen et al 2000).

A puzzling aspect of the current Swiss needle cast epidemic is concerns why the disease apparently intensified since about 1990. Periodic observations indicate that the fungus has long been present in the ar ea, and periodic disease outbreaks have been noted (Russell 1981, Hansen et al 2000). Measurement of disease symptoms of Swiss needle cast over the past four years do not indicate a rapidly developing epidemic, and suggest that at the southern coastal sit es disease severity is increasing gradually while remaining relatively constant in the northern and central sets of sites. Sites with high disease have remained high, while sites with moderate or low disease have not changed during the past four years. A lthough the disease may be becoming more serious further inland from the coast, levels of infection and defoliation have remained relatively constant over four years in individual coastal study sites. Disease severity between sites is variable however, an d within each group (north, south, central of study) sites a range of disease severity can be observed. Because the same seed source was used within each group of sites, consistent differences in disease severity between sites suggests that environmental or other site related factors are involved.

Factors that may be important in the current outbreak of Swiss needle cast are increased inoculum levels, increased acreage of Douglas -fir plantations in the coastal area and subtle climatic differences between sites that favor infection and colonization by *P. gaeumannii*. In 1997 the Oregon Department of Forestry (unpublished data) investigated the history of 76,970 ha of Douglas-fir plantations 10 – 30 years old growing within 29 km of the north Oregon Coast. About 31% of these plantations had been established on sites where hemlock and spruce had dominated the previous stand. Only 20% were on sites dominated by Douglas -fir in the previous rotation. The remaining areas were mostly alder stands that had been converted to Douglas-fir. Although historical records are scant, this at least suggests that Douglas -fir is more abundant in the coastal forests than earlier this century. Increased levels of Douglas -fir in the coastal area may be a contributing factor to the current SNC problem. If recent conditions have been favorable for development of the pathogen, then higher than normal levels of inoculum may have been produced in recent years.

Much of the land that has been converted to Douglas -fir plantations in recent decades, and where most severely affected plantations are located, lies in the *Picea sitchensis* vegetation zone, a narrow strip of coastal forest characterized by elevations generally below 150 m,

proximity to the ocean, and a moderate climate. A lthough Douglas-fir is the natural seral dominant in the *Tsuga heterophylla* Zone, which borders the *Picea sitchensis* Zone to the east, its occurrence in the *Picea sitchensis* Zone is more sporadic, and normally it occurs in mixtures of spruce and hemlock, not as pure stands (Franklin and Dyrness 1973). An increase in the proportion of Douglas-fir in recent decades, its concentration in pure stands, and favorable climatic conditions may have enabled *P. gaeumannii* to increase above historically normal levels in coastal forests, leading to increased disease pressure. Under this increased inoculum pressure, even a naturally tolerant host population may be adversely affected.

Subtle climatic differences that are primarily responsible for the different vegetati on composition of the *P. sitchensis* and *T. heterophylla* zones, also are likely important factors in disease severity. Hood (1982) found higher levels of *P. gaeumannii* in southern British Columbia and western Washington in coastal forests of Vancouver Isla nd and the Olympic Peninsula, with lower levels in the rain shadow of eastern Vancouver Island and the interior. In our plot clusters, disease symptoms are more severe and fungal colonization greatest in sites with low elevation near the coast. At slightly higher elevations and further inland, plantations of the same age and seed source have milder symptoms of disease and needle retention of 3 to 4 years on average. The fungus is still abundant, but predominantly on the older needles. Environmental diff erences between such nearby sites are subtle, but perhaps significant. Temperatures are milder and annual rainfall is actually lower closer to the coast in the *Picea sitchensis* Zone than it is at higher elevations in the Coast Range. Hood (1982) found a significant correlation between May-July rainfall and percentage of infected needles.

At our sites, measurements of leaf wetness at a temperature range where *P. gaeumannii* should be physiologically active (14-16 C) were related to differences in disease severity between sites, and the degree day accumulation 6-26 C from Dec-Feb was strongly correlated with needle colonization by *P. gaeumannii*. These observations suggest two periods of the colonization process that are influenced by climate. Factors af fecting ascospore dispersal and early establishment and growth will be influenced by temperatures and free surface moisture on foliage in the late spring and early summer. Warmer, more humid summers with frequent sporadic rain was cited by Boyce (1940) and Durrieu (1957) as an important difference between the climate of Europe and the Pacific Northwest, and possibly accounting for more severe disease observed in Europe. Sites having conditions more favorable to ascospore germination and early survival in spring-summer should have higher levels of disease.

Higher levels of colonization and more severe disease associated with mild winters suggests a second phase of colonization that is influenced by climate. Mature pseudothecia of *P. gaeumannii* do not first appear until the 10-12 mo following initial infection (Michaels and Chastagner 1984), although immature pseudothecia may appear in late fall to early winter (Hansen et al 2000, Stone unpublished). Vegetative development of the fungus occurs steadily from initial infection through the winter months and fungal biomass in needles continues to increase until needles are shed (Winton unpublished, Manter unpublished, Stone unpublished). The fungus is slow growing, and apparently incapable of the rapid coloniz ation and reproduction characteristic of many needle blights. Thus, mild winter temperatures that permit continuous vegetative growth of *P. gaeumannii* may also be favorable to increased levels of colonization and resultant disease. Superficial colonizati on of needles by vegetative hyphae of P. gaeumannii, beginning in early fall and continuing through the winter, has been observed (Capitano 1999), and may be an important proliferation phase affected by fall-winter climate. Mild winter temperatures together with spring-summer leaf wetness at 14-16 C therefore appear to be potential predictors of SNC severity and could be used as criteria for evaluating suitability of Coast Range sites for Douglas-fir.

Genetic composition of the Douglas-fir plantations may also be important. In Douglas-fir progeny tests in British Columbia (Hood 1982) seedling families originating from drier areas east of the Coast Ranges were more susceptible to SNC than families collected from wet forests near the coast. In many cases in the Tillamook area, seed used in low elevation coastal plantations originated from higher elevations in the Coast Ranges. The most severe disease symptoms in our study sites are at the Juno Hill and North Fork sites. Both sites were planted with seed designated Boundary 1800 ft, but both sites are below 400 ft elevation. It might be expected that trees adapted to climates less favorable to the fungus would have less tolerance to infection than trees from areas where conditions favor colonization and evolution of genetic resistance would have a high selective benefit.

Acknowledgments

Funding from the Swiss Needle Cast Cooperative of Oregon State University in support of this work is gratefully acknowledged.

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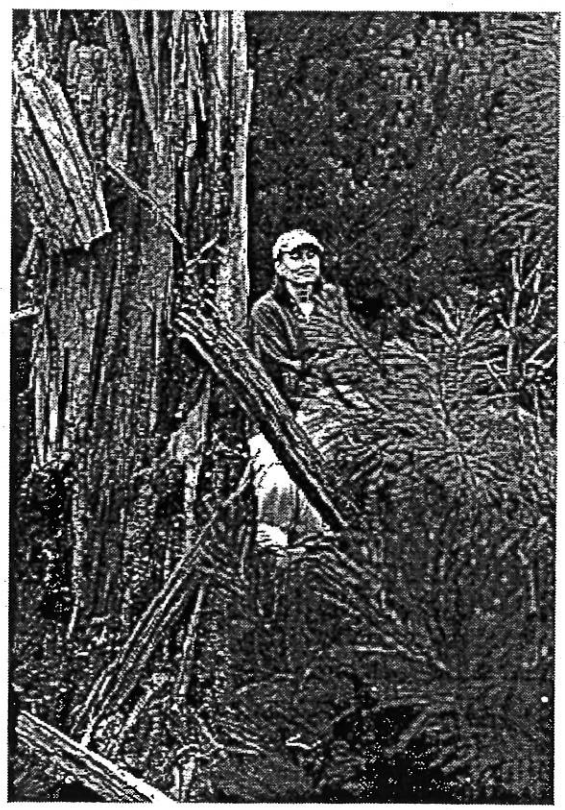

Lori Winton

Extent, Distribution, and Impact of Swiss Needle Cast Disease of Douglas-fir in Oregon

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In the forests of the Pacific Northwest, Swiss nee dle cast (caused by the fungus *Phaeocryptopus gaeumannii)* occurs throughout the range of Douglas-fir, and until recently has been considered unimportant. The earliest survey (1939) showed that the disease was widespread from northern California to British Columbia, but in no cases did it cause appreciable damage. In the late 1970's and early 1980's severe Swiss needle cast was reported in a few plantations in Oregon and Washington, but much of this damage was attributed to off-site plantings or to localized environmental conditions that favored disease development. However, since the late 1980's Swiss needle cast has become increasingly severe in plantations and in naturally established stands, particularly along the north coast of Oregon.

Extent of Damage: For four of the past six years aerial surveys of the Coast range have shown a dramatic increase in the area of Douglas-fir forest with obvious symptoms of Swiss needle cast. Most of the damaged stands are located along the north coast, particularly in Tillamook County, but damage extends south almost to the California border, and north into southern Washington.

The first Coast range aerial survey (1994) mapped concentrated damage in Tillamook County, and scattered lightly damaged stands from Toled o to Astoria, with most damage occurring within 12 miles of the coast. A more extensive survey in 1996 mapped disease symptoms on about 130,000 acres, all within 15 miles of the coast. The 1997, 1998, 1999, 2000, and 2001 surveys mapped symptoms of the disease on 160,000, 173,000, 295,000, 283,000, and 221,000 acres respectively. Obvious symptoms of the disease now occur nearly 35 miles inland from the coast in some locations (Figures 1, 2).

Survey flights over the Cascade Range in 1999 and 2001 did n ot detect obvious symptoms of Swiss needle cast, although the disease does occur there. In 2000 two flights were made over the west slopes of the Cascade Range (more than 70 miles inland from the coast), and a small amount of Swiss needle cast damage was mapped. These areas were visited on the ground and Swiss needle cast was confirmed. Symptoms in the Cascades were much less developed than in the Coast range, and trees with symptoms tended to occur infrequently and in small patches. Thus far the disease appears to be of concern only in a few localized areas in the Cascade Range.

Aerial survey results are conservative estimates of damage because observers map only those areas where disease symptoms have developed enough to be visible from the air. Permanen t monitoring plots and ground checks have shown that Swiss needle cast occurs throughout the survey area, but that symptoms often are not developed enough to enable aerial detection. In some cases the disease can be so severe that detection is difficult be cause of lack of foliage due to SNC, and the growth of non-host tree and shrub species. In this instance, severely damaged stands may not be mapped.

Winter weather also may affect symptom development. In the 1999 survey, the upper crowns of many trees were barren of needles, apparently battered by the unusually frequent high winds

during the winter of 1998-1999. The winters of 1999-2000 and 2000-2001 were relatively mild and uneventful compared to the previous two years, and may have influenced the result s of the 2000 survey.

Permanent plots in the northern Coast Range have been monitored for 5 years. The severity of Swiss Needle cast on these plots has changed little during this period. However encouraging this might seem, the continued poor condition of Douglas-fir forests suggests a continuing severe growth reduction from Swiss needle cast.

Effects on forests: The main effect of SNC on trees is reduction in tree growth which reduces yields and affects our ability to manipulate stands into desired str uctures and compositions. Hundreds of thousands of acres of Douglas-fir forest in coastal northwest Oregon are growing well below rates expected for the site. If the poor growth continues, yield expectations and harvest levels will need adjustment.

An assessment of the impact of Swiss needle cast on growth of 10 - to 30-year-old Douglas-fir plantations in coastal northwest Oregon was completed in 1997 under the auspices of the Oregon State University Swiss Needle Cast Cooperative. Recent annual volume growth of plantations in the study area averaged approximately 23 percent less than would be expected for healthy plantations. If the growth loss remains at this level through the rotation, the yield loss in the 187,000-acre study area would be more than 1.6 billion board feet. This is equivalent to about 43 million board feet per year. If the results of this study were applied to other age classes and other coastal areas, the impact would be much greater, probably about 100 million board feet per year . It is not known if the growth reduction caused by Swiss needle cast will increase, decrease, or remain constant over time.

The lack of crown closure and the loss of foliage in severely damaged stands reduces Douglas - fir's competitive vigor and allows t remendous growth of understory vegetation, which affects stand dynamics, management options, possibly wildfire behavior. In severely damaged stands, thinning may be of questionable value, and could be detrimental. We have not yet observed recovery of severely affected stands, but neither have we seen a steady decline leading to death. Infected trees are able to survive for many years, but they grow at an abnormally slow rate.

Explanations for disease increase: Several hypotheses have been suggested to explain why this normally benign pathogen is causing severe damage to Douglas -fir in its native range. Certainly the presence of the pathogen alone does not does not account for it because the pathogen occurs on Douglas-fir everywhere. One hypothesis is that a highly virulent strain of the pathogen has become established in the Coast range. Preliminary research at OSU suggests that this possibly may be a contributing factor.

The more likely hypothesis is that our management practices, in combination wit h a climate that is conducive to the disease, have shifted the ecological balance in favor of the pathogen. Much of the sitka spruce zone along the coast has been planted to dense stands of Douglas -fir. Often these plantations were established from seed collected farther inland and at higher elevations than native coastal stands. The combination of a climate favorable for the disease, an increase in the amount and density of Douglas-fir in coastal areas, and slightly off-site seed sources, may have set the stage for rapid and efficient spread of the fungus. As a result, the pathogen population may have increased to levels that can overwhelm naturally occurring mechanisms of disease tolerance.

When Douglas-fir and the Swiss needle cast pathogen are est ablished beyond their natural geographic range, Swiss needle cast consistently becomes severe and mitigation is difficult and slow. Apparently a delicate balance exists between the tree, the pathogen, the environment. Understanding the effects of variou s factors on this balance is critical for predicting long term effects on forests and for formulating practical mitigation measures.

Current Forest Management Recommendations: Reducing losses to Swiss needle cast is best achieved through cultural treatme nts (planting, thinning, etc.) rather than chemical treatments. Current recommendations are summarized below.

Establishing new plantations: In areas where Swiss needle cast appears severe (usually in the coastal fog-zone, or as indicated by aerial survey maps), plant any species other than Douglas-fir that is well-suited to the site. In areas where disease is noticeable but not severe, limit the proportion of Douglas-fir to 50 percent or less, and be sure to use seed from the appropriate seed zone and elevation.

Managing existing plantations: Decisions about existing stands should be made on an individual stand basis, and will depend on management objectives, the stocking levels of species other than Douglas-fir, and the apparent impacts of Swiss needle cast on growth. Harvesting a stand early would allow replanting with species other than Douglas-fir. Thinning is acceptable if necessary to manage stand density, but it has not been shown to reduce disease severity or to alleviate growth decline from Swiss needle cast. Observations on some sites suggest that thinning may be detrimental when the disease is severe. Inter-planting stands with species other than Douglas-fir is possible in stands less than 10 years old, but could require considerable site pr eparation to reduce competing vegetation. Pruning live branches is not advised in stands with severe Swiss needle cast because further loss of leaf area may exacerbate needle cast effects on growth. Pruning also may not be a good economic investment if t he disease threatens the future of the plantation.

Chemical treatments have met with limited success, and they continue to be investigated. The fungicide chlorothalonil (Bravo 720) has reduced Swiss needle cast in carefully controlled experiments using ground based and aerial sprays. However, aerially applied chlorothalonil has not been shown to be an economical treatment in forests and currently is not recommended. Aerial applications of sulfur also show some promise, pending results of field trials.

Fertilization with nitrogen and/or phosphorus has not improved the condition of diseased stands significantly, so they are not recommended. Applications of complete blended fertilizers with micro-nutrients are being evaluated, but early results are not p romising.

Research and Monitoring Activities: Aerial and ground surveys to monitor changes in the disease over time are conducted annually by the Oregon Department of Forestry (ODF) Insect and Disease section, with cooperation from the US Forest Service. Approximately 2.9 million acres are surveyed from the air each year.

Most Swiss needle cast research is now coordinated by the Oregon State University Swiss Needle Cast Cooperative (SNCC), which began in early 1997 as a coalition of about 17 companie s and agencies from Oregon and Washington (mostly Oregon). Major topics of investigation include: 1) monitoring changes in the extent and severity of the disease; 2) estimating impacts of the disease on tree growth; 3) describing the biology and ecology o f the pathogen; 4) understanding the physiological response of Douglas-fir to the disease; 5) evaluating the effects of thinning on

disease; 6) screening for genetic tolerance within the Douglas -fir population, and; 7) evaluating chemical and cultural treatments to mitigate damage.

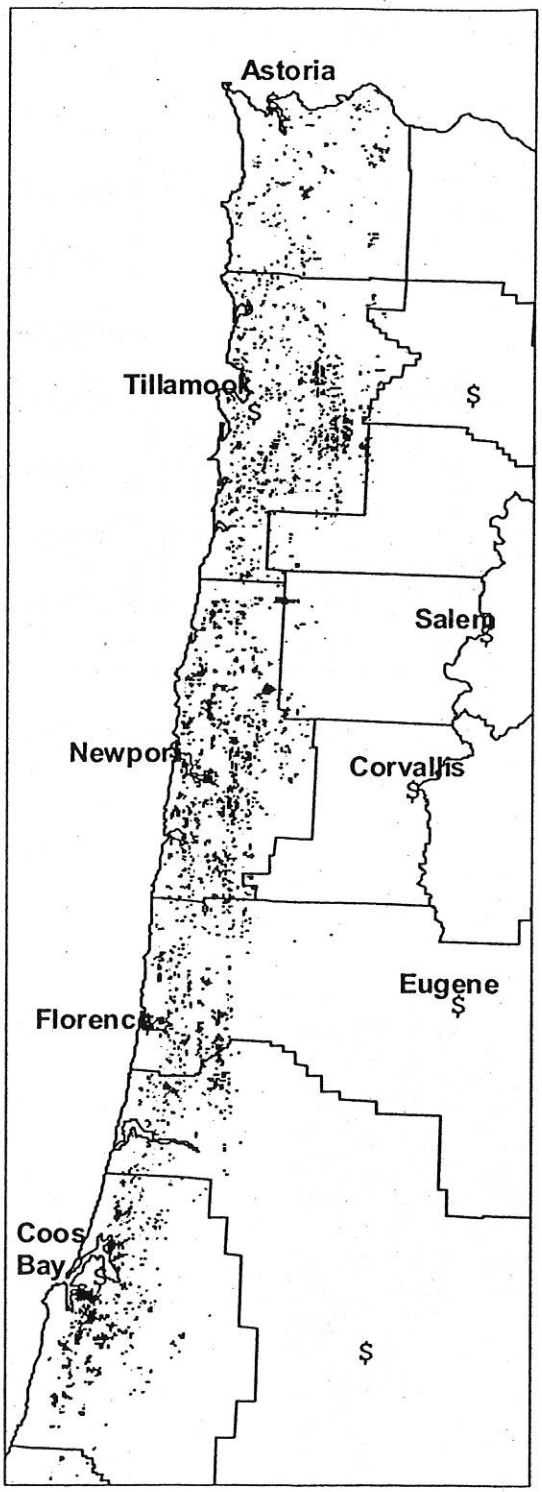


Figure 1. Area of Douglas-fir forest in western Oregon with symptoms of Swiss needle cast, as detected in aerial surveys, May, 2001.

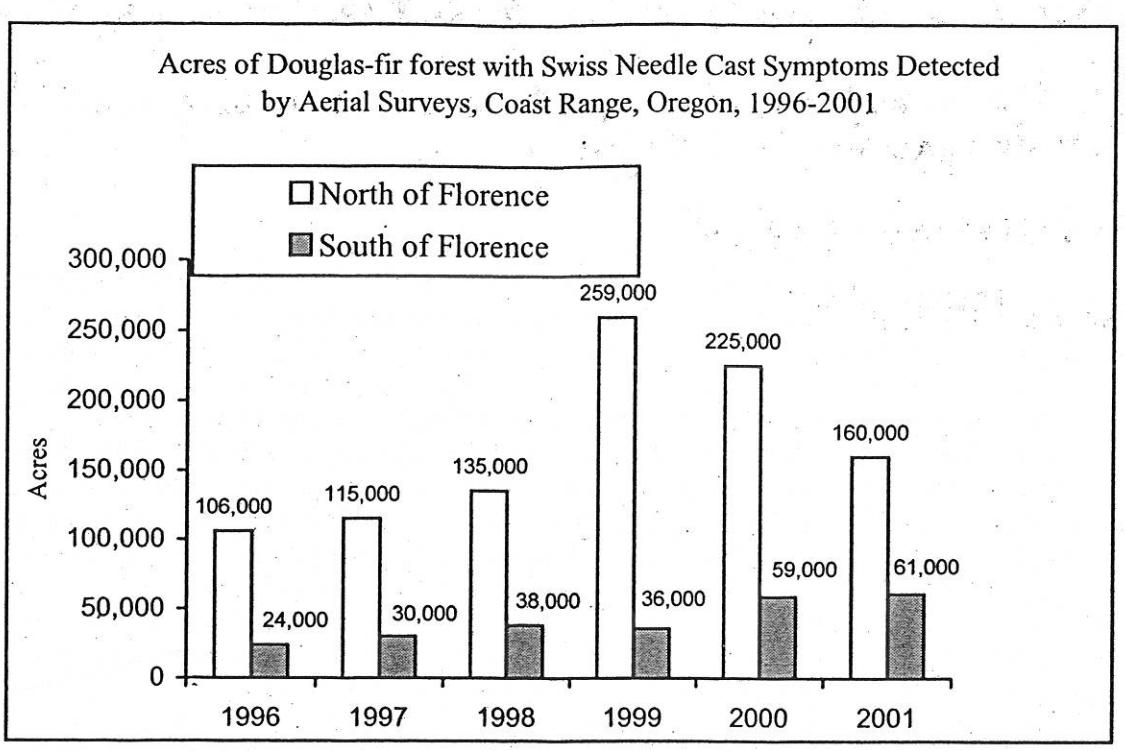
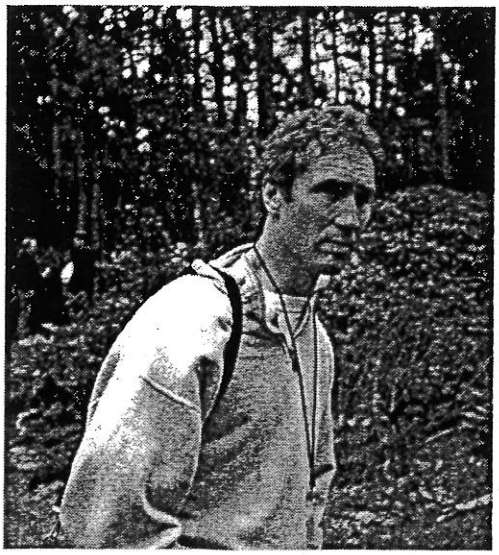


Figure 2. Trend in Swiss needle cast damage as detected by aerial surveys, 1996 -2001, western Oregon.



Alan Kanaskie

Getting to know *Phaeocryptopus gaeumannii* through DNA

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A hierarchical series of studies, based mainly on molecular data, was conducted to elucidate the life history of the Douglas-fir Swiss needle cast pathogen *Phaeocryptopus gaeumannii* at macro- and micro-evolutionary scales. This information was then utilized to design and evaluate molecular diagnostic tools for use in studies on the epidemiology of a Swiss needle cast outbreak near Tillamook, Oregon.

Phylogenetic analyses of partial nuclear ribosomal gene sequences indicated that *P. gaeumannii*, currently classified in the Venturiaceae, is closely related to neither *Phaeocryptopus nudus*, type of the genus, nor *Venturia inaequalis*, type of the Venturiaceae (Figure 1). Instead, it is closely related to members of the "sooty molds" (Capnodiales), particularly the common and morphologically similar Douglas-fir epiphyte *Rasutoria pseudotsugae* (Euantennariaceae).

Single-strand conformation polymorphisms, revealing DNA sequence variation in five loci, were used to investigate population biology of *P. gaeumannii* from a worldwide collection of isolates. In western Oregon, *P. gaeumannii* population structure suggests a predominantly selfing reproductive mode within two reproductively isolated sympatric lineages. One lineage was widely distributed both locally and abroad (Figure 2). The second lineage was restricted to western Oregon and suggested a correlation with symptoms of Swiss needle cast.

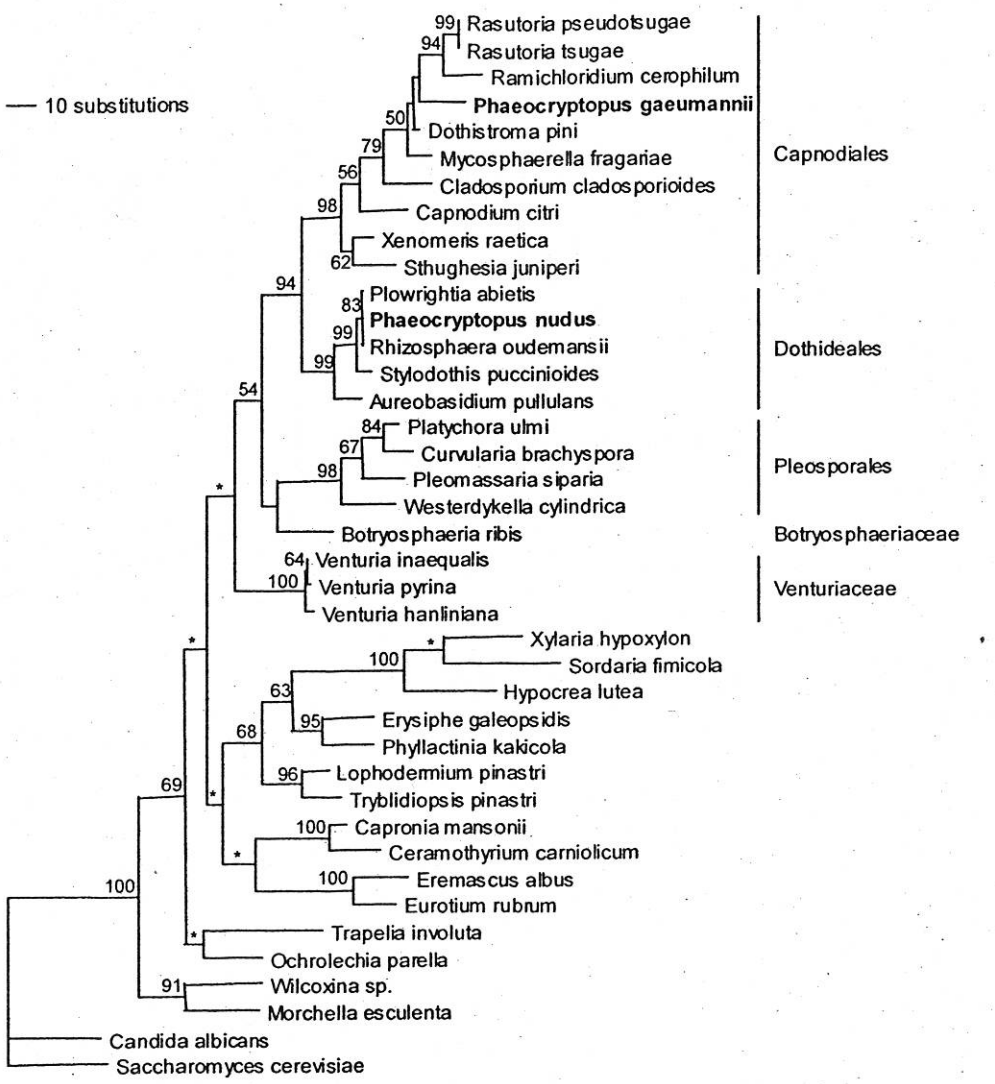

Figure 1. Best (-ln likelihood) of 32 equally most parsimonious trees and 1 neighbor -joining tree. This tree resulted from maximum parsimony analysis of LSU rDNA. Bootstraps values >50% are presented at the nodes and nodes that collapsed in the strict consensus tree are marked by *. *Phaeocryptopus* species are indicated in bold and vertical bars to the right indicate classifications of monophyletic groups of loculoascomycetes. The scale bar represents the number of nucleotide substitutions along a branch.

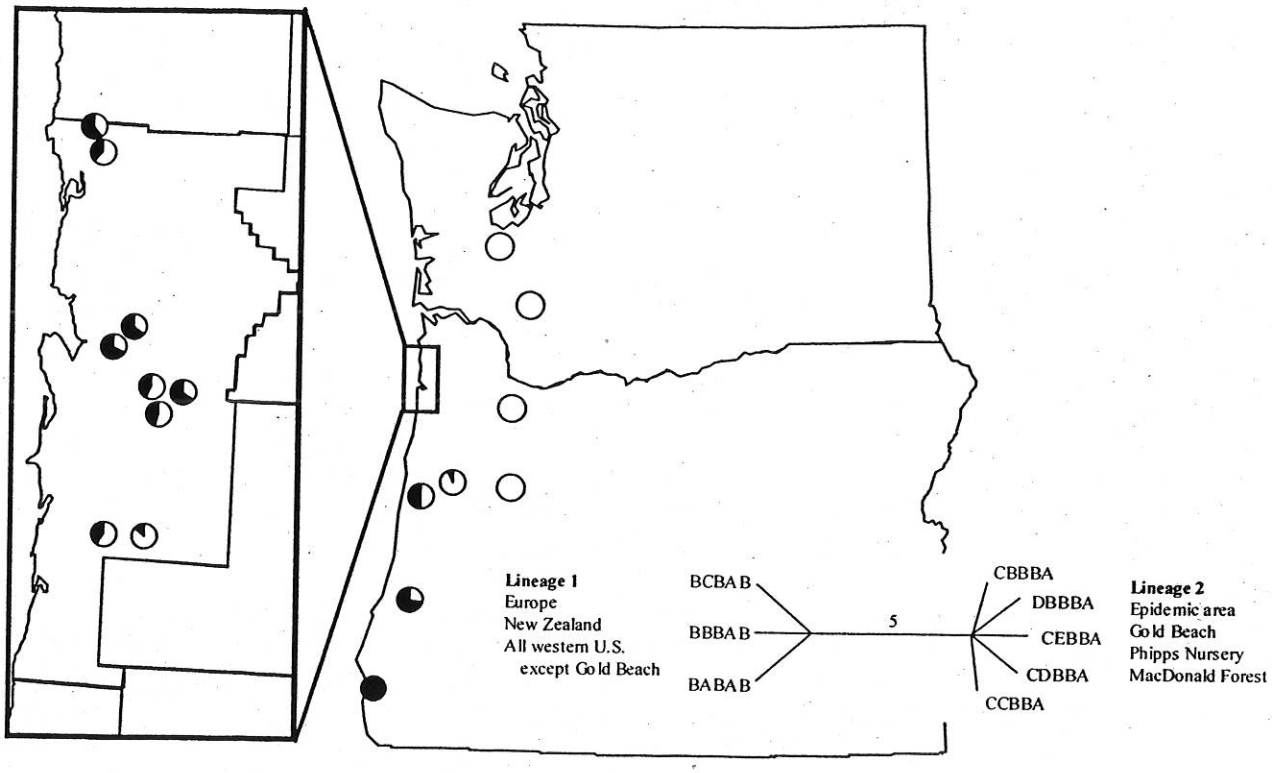

Figure 2. Relative proportions of lineages 1 (○) and 2 (●) and their distribution in Oregon and Washington Douglas-fir stands. Inset shows Tillamook County, the area with the greatest incidence and severity of Swiss needle cast.

A novel application of real-time PCR allowed species-specific detection and quantification of *P. gaeumannii* and proved a good measure of its biomass in Douglas-fir needles. Compared to other techniques (ergosterol and a DNA probe), real-time PCR correlated best with visual estimates of needle colonization and additionally proved useful early in the first year of the colonization process before visible development of fruiting structures (Figure 3). While all four methods provided evidence that sites expressing a range of disease severity differed in the degree of fungal colonization, only real-time PCR consistently separated both moderately and severely diseased sites from relatively healthy sites.

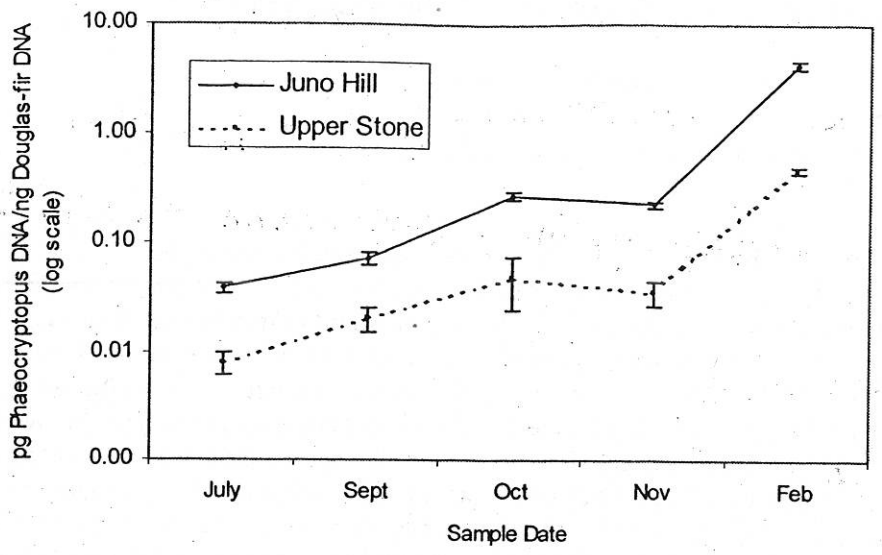

Figure 3. Real-time PCR (TaqMan) estimates of *P. gaeumannii* DNA in current year needles collected periodically from the two most extreme sites in the Tillamook cluster. Verticle bars represent standard error of the means. Bud-break, and ascospore infection, began in late May 1999, about 6 weeks before the first sample collection. Bud-break at Upper Stone began about 4 weeks before the first collection date. Recognizable pseudothecia ini tials were first observed in February 2000 at Juno Hill and in April 2000 at Upper Stone.

Seedling inoculation experiments, fulfilling Koch's postulates, demonstrated that *P. gaeumannii* is the causal agent of Swiss needle cast, as observed in the Tillamo ok epidemic (Figure 4). Furthermore, the incorporation of virulence tests provided independent, non - molecular evidence that Oregon's pathogen population is not homogeneous. One strain, isolated from a severely diseased site, caused significantly greater symptom severity than strains derived from less damaged sites.

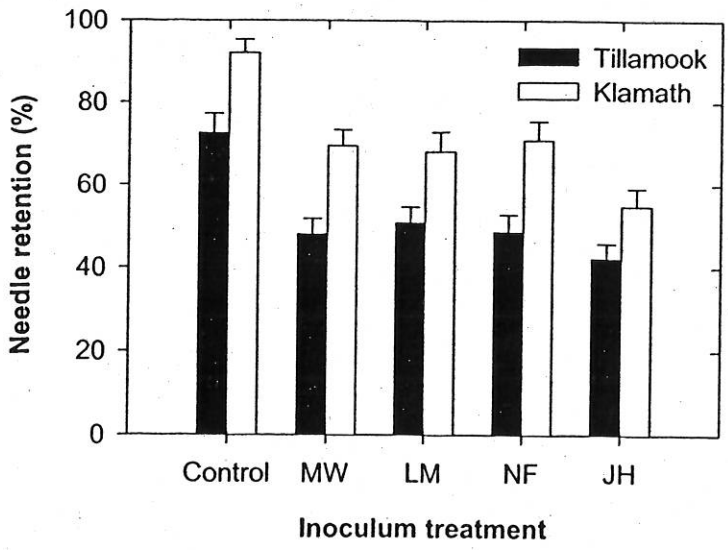

Figure 4. Percentage of needles retained on Tillamook and Klamath Falls seedlings 16 months after inoculation with isolates of *P. gaeumannii* (MW, Menagerie Wilderness; LM, Limestone; NF, North Fork; JH, Juno Hill). Error bars show one standard error.

Influence of the *Phaeocryptopus gaeumannii* on Net Canopy Carbon Assimilation, Needle Abscission and Growth in Douglas-fir

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A process-based photosynthesis model was used to estimate hourly rates of needle carbon assimilation for several Douglas-fir needle ages. The model accounts for the impacts of climate and the stomatal and non-stomatal limitations to CO_2 assimilation imposed by the endemic foliar fungus, *Phaeocryptopus gaeumannii*. Estimates of yearly needle carbon budgets became negative after 25 % of needle stomata harbored visible fungal fruiting bodies of *P. gaeumannii*. However, on a whole-tree level all modeled trees maintained a positive canopy carbon budget for the model year due to the large contribution of carbon assimilation from current -year needles. For example, greater than 50 and as much as 100 % of the total canopy CO_2 assimilation occurs in the current year foliage for high and low disease sites, respectively. In the following spring, all needle age classes with negative carbon budgets were completely abscised helping to maximize whole-tree net carbon assimilation. A single linear relationship between above-ground volume growth and yearly net canopy carbon assimilation was observed for all trees regardless of site microclimate or disease level. Furthermore, it was estimated that *P. gaeumannii* is reducing net CO_2 assimilation in western Oregon Douglas-fir plantations by ca. 1.9×10^6 metric tons annually.

PANEL: DETECTING AND MONITORING FOREST PATHOGENS - INTERPRETING SPATIAL DATA, ROADSIDE SURVEYS AND INVENTORY PLOT DATA

Moderator: Sally Campbell, USDA Forest Service, Portland, Oregon

Forest Pest Surveys: Designing Methods for Newly Introduced Diseases or Other Rare Event, Unevenly Distributed Organisms

Walter Mark

Professor, Natural Resources Management Department, Cal Poly State University, San Luis Obispo, Co-Chair COMTF Monitoring Committee

ABSTRACT

Forest pest surveys are often requested of resource professionals to provide information on new or existing pest conditions. These often are a problem, since funding frequently does not accompany the request. The objectives of the surveys may not be well thought out leading to problems with the design of the survey and the analysis of the results. These problems lead to over and under reporting of the event. In addition pest problems may be similar to rare plants in terms of distribution and occurrence. The surveys need to be designed to find and report rare events, while providing adequate coverage of potential sites. Aerial surveys are particularly useful as an initial inventory tool for overstory species tha t exhibit visual symptoms; however, aerial survey results require ground truthing for confirmation of the specific pest. Understory species require ground surveys designed to capture the symptomatic trees. Each survey must be designed for the specific pest and the specific host distribution. Population or frequency estimates require some type of plot transect method of survey. One method that has proven very successful for clustered events is the adaptive cluster sampling method.

FOREST PEST SURVEYS

Data on forest pests is needed for a variety of reasons, including regulatory needs, control project planning, assessment of control projects, pest monitoring, spread monitoring, and research. Foresters and pathologists are often asked for data regarding t he distribution, frequency, host range and certification of disease free for a variety of forest pests. Providing this type of data is problematic since the data requests often are not funded, may cover extensive areas, sample for rare events, and may not be designed for the specific host-pest situation. The pest survey data frequently comes from another survey with a different original purpose and may miss or over report the pest. This is often the case because of the strong desire to be sure to include the pest in the survey area.

SUDDEN OAK DEATH BACKGROUND

Sudden Oak Death (SOD) caused by *Phytophthora ramorum* is an apparently introduced pest in California. The disease was first discovered in Marin County California in 1995 and shortly thereafter in Santa Cruz County. It was later determined that *P. ramorum*, then unnamed was known as early as 1993 to affect Rhododendrons in Europe. Since the first discovery in California in 1995, *P. ramorum* has now been confirmed by isolation in ten counties in Ca lifornia as well as in Southern Oregon. The California State Board of Forestry (BOF) established a Zone of Infestation for SOD to include all counties with SOD, and the California Department of Food

and Agriculture (CDFA) has implemented regulations restricting the movement of plant material with *P. ramorum*. Oregon has established a quarantine to attempt to prevent the importation of *P. ramorum* from California. Canada has also established a quarantine with the same objective. The enforcement of these quarantines and Zone of Infestation requires detailed knowledge of the distribution of SOD in California. The determination of the distribution of SOD is the purpose of the statewide survey for SOD.

HOST RANGE

Phytophthora ramorum was first noticed on oaks and tanoak in California and due to the symptoms of apparent rapid death and retention of dead foliage was named Sudden Oak Death. The known host range in California has now been expanded and includes many hosts outside of the family Fagaceae. Plant species from five families native to California are now known to be hosts of *P. ramorum*: Fagaceae – *Quercus agrifolia, Q. kelloggii, Q. parvula* var *shrevei, Lithocarpus densiflorus*; Ericaceae – *Arbutus menziesii, Arctostaphylos* sp., *Vaccinium ovatum*; *Rhododendron* sp.; Lauraceae – *Umbellularia californica*; Hippocastanaceae – *Aesculus californica*; Aceraceae – *Acer macrophyllum*.. SOD exhibits varied symptoms on different hosts ranging from cankers and stem bleeding to foliar leaf spots.

DISTRIBUTION OF SOD

There are currently 90 cases of SOD in California confirmed by isolation of *P. ramorum*. There are many more cases; however, a confirmed case is required to act under the regulations. Most of the current distribution is known from isolation work done at the UC Davis laboratory of Dr. Dave Rizzo. This lab continues to confirm new areas of SOD and to support researchers in their efforts to learn more about SOD. Additional isolations from within the known range of SOD are currently being confirmed by the CDFA. The known distribution of SOD has been determined by looking for visual signs and symptoms of the disease on plant hosts where the disease is suspected. Much of this work has been done through reports of declining oaks or other hosts and by road survey work in areas where susceptible hosts occur.

The discovery of SOD in Oregon was accomplished through aerial surveys of areas where tanoak were present. From this survey 27 suspect areas were identified. Eleven of these were selected for ground checking and from those the pathogen was recovered from five separate sites.

An aerial survey of eight counties in California where SOD has been confirmed was conducted on July 5, 6, and 9, 2001. The purpose of the aerial survey was to determine the incidence and severity of oak and tanoak mortality in coastal California and to provide baseline data to monitor SOD. This survey resulted in mapping of 60 polygons representing 44,823 acres. Of the 60 polygons, there were 59 with tree mortality, 44 of which had mortality believed to be from SOD. Ground checks of the polygons suspected to be SOD are continuing at the present time. This aerial survey represents the most complete survey to date of the extent of SOD.

No extensive survey for the presence of SOD has been done in areas outside the known infested counties, with the exception of southwestern Oregon. Aerial survey has also been done in Humboldt County. Regulatory actions of CDFA and BOF require that a systematic survey of areas outside the infested area be done to determine the presence or absence of SOD.

STATEWIDE SURVEY

Survey work for SOD on a statewide basis is similar to a rare plant survey. Such surveys are undertaken to determine the presence and location of rare species or events in a study area. While these surveys can confirm the presence of the rare event, they can seldom conclusively rule out the occurrence of the rare event in the study area. Traditional survey methods focussing on

vegetation community classification are inappropriate and i nefficient for rare event surveys. Quantitative vegetation analysis techniques tend to represent dominant vegetation species on a site and focus effort on small portions of a study area. Rare plants or rare events usually have small discrete populations or tend to be thinly scattered on a landscape. As a result, they are more likely to be found by concentrating search efforts than by surveying larger areas. When the search area is too large to allow a detailed inspection of the entire area, searches sho uld concentrate on as many likely sites as are feasible while still sampling each habitat represented in the study area. Search efforts should be pre-stratified to more intensely sample sites with a high probability of supporting the rare event. Systemat ic search patterns are recommended to minimize overlap and maximize coverage.

Work on the statewide survey was started in the fall of 2001 following the protocol outlined at the August 30, 2001 meeting of the COMTF Monitoring Committee Meeting. The sta tewide survey will be conducted utilizing systematic aerial survey followed up with ground validation for sample collection to confirm the presence of *P. ramorum*. The areas to be surveyed will be determined by the use of host distribution mapping, risk ma ps, and areas that have been identified with canopy changes from remote sensing monitoring. The survey area will be concentrated in counties adjacent to those with confirmed SOD, boundary counties, and in areas where the risk and host ranges indicate a h igh probability of the presence of SOD. As the known confirmed distribution of SOD expands, the area of the statewide survey also must be expanded to include additional boundary counties. The current boundary county survey covers parts of 20 counties from San Luis Obispo in the south to Del Norte in the north.

Prior to aerial survey work, host distribution maps and risk maps are prepared for flight planning. This stage of the effort is occurring at the present time. Vegetation maps are being prepare d using the GAP Analysis database and the CDF Hardwood Management database. These two sources are prepared at different intensities and provide somewhat different information, but in combination provide a good indication of the location of potential host communities. Risk maps are utilized to plan the flight lines and to prioritize the survey areas. Some of the factors that are included in the risk mapping include: proximity to confirmed SOD cases, host species presence, summer fog zone, precipitation, maximum summer air temperature, minimum January air temperature, and proximity to roads and parks.

Aerial surveys are conducted in late spring from fixed wing aircraft flying at altitudes between 500 feet and 2000 feet above the ground. Airspeed is appro ximately 80 knots. Flight lines are preplanned based on the area to be surveyed, host distribution, and risk maps. The timing of the aerial survey is critical for success in detecting SOD suspect areas. The flights must be conducted late enough in the spring that moisture stress and visible symptoms are expressed in infected hosts. The flights also have to be conducted early enough that drought deciduous species, such as California buckeye, are not starting to fade due to normal leaf drop. The flight lines are continuously recorded using hand-held GPS. Areas of mortality are mapped as point features along the GPS'd flight lines and are hand sketched on orthophoto GIS maps showing vegetation and other visible features. The scale of the orthophoto maps is 1:15,000. Still photos are taken of the infested areas to aid in location of the specific area in the ground validation.

Ground validation is conducted for mapped areas that are identified as suspected SOD infections. The combination of the orthoph oto mapping, still photos, and the GPS data are used to locate the suspect areas on the ground. Land ownership must be established to provide for access to the suspect areas for sample collection. Sample collection will proceed utilizing the Regulatory Sampling Guidelines for Sudden Oak Death (*Phytophthora ramorum*)-Infected Foliar and Wood Hosts approved at the August 30, 2001 COMTF Monitoring Committee Meeting.

Aerial survey techniques do not work for understory species or species only exhibiting foliag e symptoms. Techniques for surveying these species on a statewide basis have only recently been developed. The tasks for such survey work includes host distribution mapping, risk mapping and ground checking of high risk areas to collect stem and foliage samples for isolation work. The ground validation of high-risk areas will involve one of two methods for survey work. The method applied will depend upon the characteristics of the area to be checked. Meander searches will be used in irregularly shaped areas, such as riparian communities. Patterned searches will be used in areas where the community covers larger areas with varied habitats. A standard 2 % Animal and Plant Health Inspection Service (APHIS) sample of survey areas is planned for this survey work.

One additional survey methodology has been developed and approved for use for SOD, that is the "Free From" survey. This type of survey is necessary to obtain a permit to move restricted plant materials of known host species within infested counti es. This survey will be conducted in three different ways depending upon the land management and the proximity to known SOD cases. For "Free From" surveys for areas within 2 miles of the 1/4 mile radius confirmed site area, a 10% survey must be conducted. This survey should by done by transect method with transects designed to cover all suspect habitat types. For areas outside of a 2 -mile radius from a confirmed site, a 2% transect survey with similar design criteria must be conducted. In both cases a ll suspected SOD cases would have sample collections made for isolation testing at a CDFA laboratory. In areas where the proposed movement of potential host material is associated with a Timber Harvest Plan (THP), the Registered Professional Forester (RPF) or the RPF's designee or a certified Forest Health Specialist shall conduct the survey. The RPF must be trained in a California Department of Forestry (CDF) approved training program. The RPF is responsible for training any designees working on the "Fr ee From" survey. Survey work will be conducted at all levels in the preparation and implementation of the THP. This will include inventory, pre -sale reconnaissance, sale layout, timber marking, timber felling, timber yarding, and slash disposal. Any suspected cases of SOD will be reported to the local County Agricultural Commissioner's Office and will require sample collection for laboratory isolation work at a CDFA laboratory.

PEST INTENSITY SAMPLING

Sampling for pest intensity or frequency over large areas has long been a problem. Specialized sampling techniques must be utilized to accurately reflect pest populations. One of the most accurate methods is a variation on the plot transect survey technique. This is called adaptive cluster sampling (ACS) and has been used successfully on clustered tree problems such as defoliators, root rots, dwarf mistletoe, and bark beetles. The method is cost effective because the increased sampling intensity is only implemented when the event is found in the survey area. The plot size can be varied depending upon the pest and the frequency of the events. The plot data can be analyzed to determine the sampling intensity and the survey modified as needed based upon the variability of the plots. A suggested sampling confidence level for pest surveys is 90 percent. In the ACS method if an event is found in a plot, that becomes a new plot center and new plots are established until no event occurs in the newly established plot. The data from this type of survey allows for an estimate of the total frequency of the pest and the accuracy can be reported as a confidence level.

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Oregon Aerial Surveys - Accuracy and Interpretation

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Aerial surveys for damage to forest trees caused by insects and diseases have been conducted annually in Oregon for more than 50 years. For most of this time, insects were the primary focus of the surveys. In recent years aerial surveys have been used to detect and quantify damage caused black bears, Swiss needle cast, Port-Orford-cedar root disease, and Sudden Oak death.

In some cases, users of the information wanted the simplest of maps to sho w approximate locations of damage, while in others, the survey was used to calculate precise estimates of the amount of damage over the millions of square miles surveyed. The various surveys had unique objectives, and their design and interpretation reflec t these objectives. Ground-verification of the aerial surveys allowed us to describe survey accuracy and clarify the interpretation of results. In some cases, such as the bear damage survey, coupling the aerial survey with ground plot data was essential for meaningful interpretation of results.

The discussion that follows describes the aerial survey and ground -verification methods, the accuracy of sketch maps and damage identification, and suggests appropriate interpretation of the survey results. Because the surveys differ from one and other, they are discussed separately.

SWISS NEEDLE CAST SURVEY

Objective: To monitor the extent and distribution of Swiss Needle cast in western Oregon

Survey procedures: The observation plane flew at 1,500 to 2,000 feet above the terrain, following north-south lines separated by 2 miles. Observers looked for areas of Douglas -fir forest with obvious yellow to yellow-brown foliage, a symptom of Swiss needle cast. Patches of forest with these symptoms (referred to as polygons) were drawn onto 1:100,000 scale topographic maps. Each polygon was classified for degree of discoloration as either "S" (severe) or "M" (moderate). Polygons classified as "S" for discoloration had very sparse crowns and brownish foliage, while those classified as "M" were predominantly yellow to yellow -brown foliage and slightly more dense crowns than those classified as "heavy".

In 2000 and 2001, observers used a computer-based sketch-mapping system linked to a real-time Geographic Positioning System (GPS). Observers recorded damage onto computer touch screens that displayed topographic maps and the position of the aircraft. This technology allowed observers to spend less time navigating and more time mapping, and generally increased precision and accuracy compared to previous surveys using paper sketch maps. Paper maps were used from 1996 to 1999.

The Coast range was surveyed each year between mid -April and mid-May. The area surveyed extended from the coastline eastward until obvious s ymptoms were no longer visible, and from the Columbia river south to the California border.

Ground verification consisted of checking a subset of polygons to determine whether or not the polygons represented Douglas-fir stands with Swiss needle cast damage. In addition, approximately 100 ground plots were established in the survey area to assess severity of Swiss needle cast damage.

Results and discussion: The 2001 Coast Range survey covered about 2.9 million acres of forest. Figure 1 shows the approximate size and location of areas of Coast range Douglas-fir forest with symptoms of Swiss needle cast detected during the survey conducted in 2001. Approximately 221,000 acres of Douglas-fir forest had obvious symptoms of Swiss needle cast: 160,000 acres north of Florence, and 61,000 acres south of Florence. This is a decrease of about 62,000 acres compared to the 2000 survey (figure 2). Most of the decrease in the number of acres with symptoms occurred North of Florence. South of Florence, the number of acres with symptoms increased by about 2,000 acres between 2000 and 2001. The easternmost area with obvious SNC symptoms was almost 35 miles inland from the coast, which is a slight increase compared to previous surveys. Most of the areas with symptoms that can be detected from the air occurred within about 18 miles of the coast.

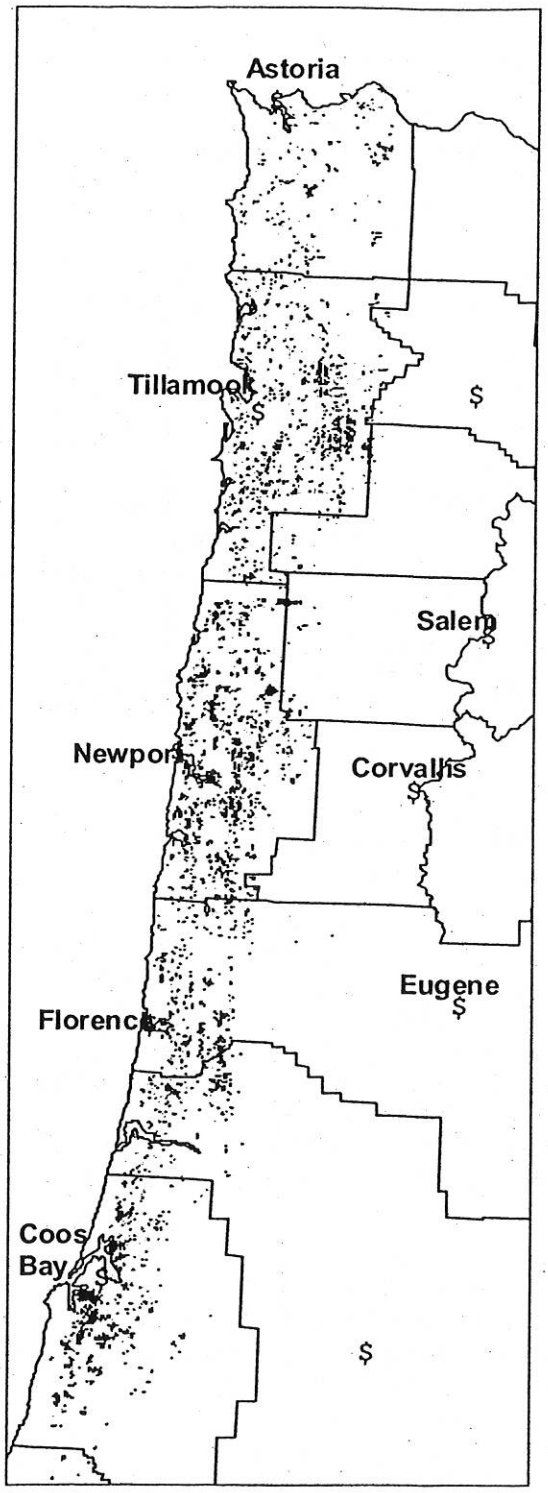

Figure 1. Areas of Douglas-fir forest with symptoms Swiss needle cast damage, Coast range of western Oregon, 2001.

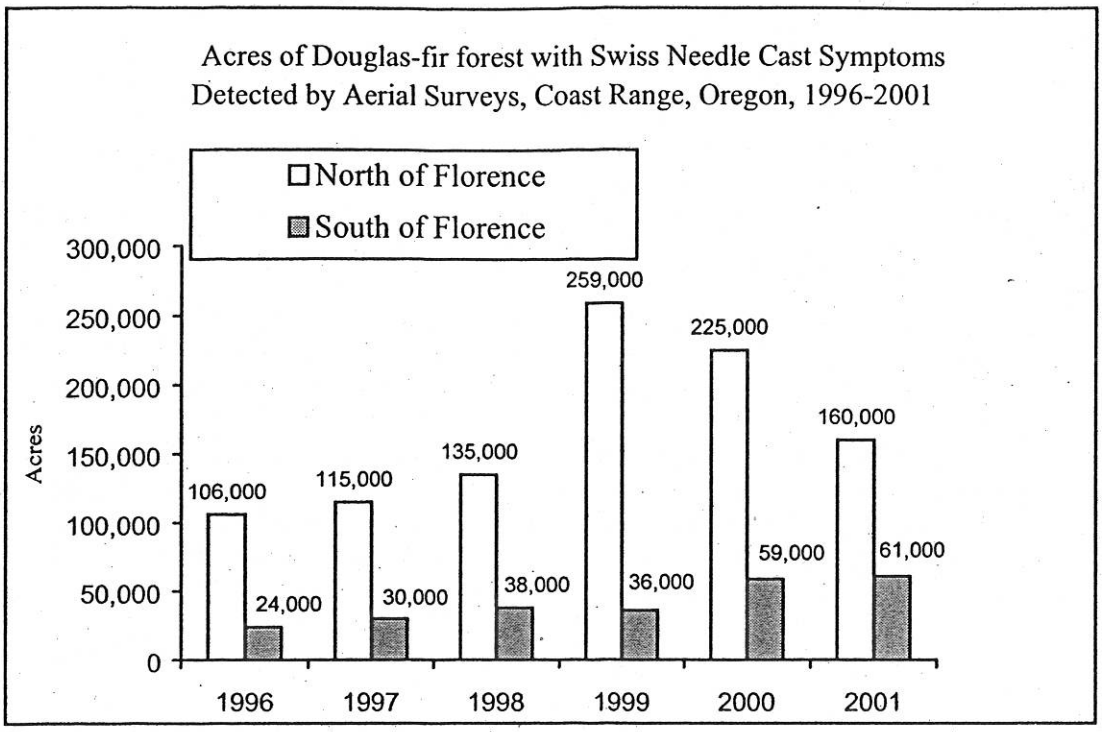

Figure 2. **Trend in Swiss needle cast damage in the Coast range of western Oregon, based on aerial surveys conducted in April and May of each year.**

We visited 100 disease monitoring plots located in the northern half of the survey area and compared disease severity ratings of plots that occurred within aerial survey polygons to those that were not in polygons. Disease severity was determined by measuring needle retention (in years) for each third of the live crown and calculating an average for the tree. Ten trees were sampled per plot. Swiss needle cast was present and damaging on all plots. Disease severity was slightly greater (significant at the .01 level, students t-test) in plots that occurred within aerial survey polygons than in those outside of polygons. These results show that Swiss needle cast occurs throughout the survey area, but that symptoms often are not developed enough to enable aerial detection.

Factors other than the presence of the pathogen strongly affect disease development, and these factors remain poorly understood. The shape and distribution of survey polygons and the observer's comments suggest that symptoms are most obvious on southerly aspects and on exposed ridge tops, indicating a strong environmental interaction.

Winter weather also can affect symptom development. During 1999 ground checks, brown needle tips were observed commonly, and may have resulted from cold temperatures during the week before Christmas in 1998. However, this brownish discoloration was restricted to Douglas-fir, and even if it was partly due to low temperature injury, Swiss needle cast was an important factor as well. The upper crowns of many trees were barren of needles, apparently battered by the unusually frequent high-winds during the winter of 1998-1999. The winter of 1999-2000 was relatively mild and uneventful compared to the previous two years, and probably exerted little direct influence on the results of the 2000 survey.

Some year-to-year variation in survey results is due to the timing of the flights. Because symptoms develop rapidly during April and May, later surveys detect more areas with symptoms than those conducted earlier. This was very evident in 1997 when a few extra days of surveying at the time of bud break increased the estimate of acres with symptoms from 145,000 to 393,000. This happened again to some degree in 1999, when about half of the survey was completed between April 21 and April 30, and the other half on May 21 and 22. However, the unseasonably cool spring temperatures in 1999 delayed bud-burst by about 2 to 3 weeks compared to previous years, so even though much of the survey was completed in late May, it was well within the target surveying window. Had the survey been flown later (in early June), we undoubtedly would have mapped even more acres of heavy discoloration during 1999.

In the early years of Swiss needle cast surveys, young western hemlock stands frequently were mistaken for Douglas-fir with Swiss needle cast damage. With increased experience, observers were able to distinguish between the two, and eliminate this source of error.

The Swiss needle cast survey is a very coarse survey with many variables affecting the results. It established broad zones in which Swiss needle cast is a significant concern, and describes trends in damage over time. The acreage estimates greatly underestimate the extent of the disease, and should not be used for calculations of economic impact or to strictly define areas where management should be altered. Management decisions should be made at a local scale based on field assessments of disease severity.

BEAR DAMAGE / TREE MORTALITY SURVEY

In the Pacific Northwest, black bears damage forest trees in the spring of the year by peeling the bark and eating the cambium. If the entire circumference of the bole is peeled, the tree will die. These trees usually become visible from the air approximately one year after the damage occurs.

Objectives: The long-term objectives of the bear damage / tree mortality survey were: 1) to document the region-wide trend in bear damage, and 2) to indicate to forest landowners the approximate location of recent tree mortality that probably resulted from bear damage.

Additional objectives included: 1) To estimate the amount (acres and trees) and distribution of recent tree mortality caused by bear and other agents in conifer forests of northwest Oregon; 2) To estimate the number and volume of trees killed by bears annually; 3) To identify the various causes of tree mortality that produce visible symptoms in June; 4) To evaluate the effectiveness of the aerial survey at detecting bear damage, and; 5) To determine the accuracy of aerial sketch-mapping of tree mortality.

Methods - Aerial Survey: The tree mortality/bear damage aerial survey was flown between June 11 and June 23, 2000 at approximately 1000 feet above the forest canopy in the Oregon Department of Forestry twin-engine Partenavia aircraft with a pilot and two observers. Seven separate flights were made over this period, with a total flying time of 34 hours. Average air speed was 90 miles per hour. Survey lines were oriented north/south at three-mile intervals. The total forested area in the survey was approximately 6.4 million acres: 4.1 and 2.3 million acres in the Coast and Cascade blocks respectively.

Aerial observers recorded the location of recently dead trees (trees with red, brown, or yellow foliage indicative of recent or imminent tree death) by drawing either a point or a polygon on a computer touch screen linked to a real-time Global Positioning System (GPS). The screen

displayed a USGS 1:100,000 topographic map enlarged to appear on the screen at a scale of about 1:42,000, and also showed the location of the survey aircraft. Using the touch screens, observers digitally recorded the size, shape, attributes, and location of the polygon.

Observers classified their sketch of a patch of dead trees as either a point or a polygon. Points had no area estimate attached to them, while the area of a polygon (in acres) was computed from the sketched figure. Aerial observers cannot accurately draw to scale polygons representing less than five acres. Although some polygons had a computed size of less than 5 acres, these are not meaningful size estimates and should have been recorded as points. For sampling and analysis we assigned an area of five acres to all points, and to polygons with a computed area of less than 5 acres.

For each point or polygon, the observers estimated the number of recently killed trees, and the probable casual agent (bear, Douglas-fir bark beetle, other). Only trees with red, brown, or yellow foliage were counted; dead trees without needles were not counted. Aerial observers distinguished bear-damaged trees from trees killed by the Douglas-fir bark beetle based on tree size and pattern of damage. Mature (>12 inches dbh) dead Douglas-fir in tight groups was coded as Douglas-fir beetle mortality. All other mortality was considered bear damage unless an obvious other cause was evident.

After the survey flights, data were downloaded and translated into GIS format. Maps were produced in ArcView, and a list of polygons was compiled. Each polygon had the following attributes: 1) a unique identification number; 2) latitude/longitude of polygon center (computed); 3) area; 4) number of recently dead trees as seen by aerial observers, and; 5) whether it was a point or polygon.

Methods - Ground Survey: The ground verification was composed of two separate samples of polygons. One was the "cooperator sample" and the other the "helicopter sample". The cooperator sample polygons were intended as an extensive and relatively rapid way to verify the polygon locations and to estimate the proportion of polygons with bear damage and the acreage represented by them. The helicopter sample involved intensive plot measurements that were used to estimate the amount of tree damage in relatively fewer polygons than in the cooperator sample.

The sample polygons were chosen with the probability of selection proportional to size (PPS), with size defined as the number of recently killed trees in the polygon. PPS sampling ensured that we sampled across the range of polygon sizes, which is particularly important for bear damage surveys because occurrence of damage is correlated with polygon size (number of trees) and polygon area (acres). Secondly, it allowed all dead trees mapped by the observers an approximately equal chance of being selected for ground verification. Without PPS, our sample would have been almost entirely very small polygons with little probability of containing bear damaged trees.

Cooperator Sample: From the list of all polygons coded as "bear damage" by the observers, we selected 150 polygons for ground verification by cooperators, 100 in the Coast Block, and 50 in the Cascade block. The probability of selection was proportional to the number of dead trees in the polygon as recorded by aerial observers (polygons with many trees had a greater chance of selection than polygons with few trees).

Once the polygons were selected we overlaid the polygons with a 1992 GIS ownership layer to determine the probable ownership and the nearest cooperating landowner. We then produced individual maps at 1:15840 (1 mile = 4 inches) showing roads, streams and topographic lines

(example attached), and distributed them to the appropriate cooperators and field crews. If a sample polygon was located on land with an unidentified or non-cooperating owner, we sent the maps to a nearby cooperating landowner.

Cooperators determined or confirmed ownership of the sample polygons and made the necessary contacts with landowners for access and permission. Using the maps provided, the latitude/longitude coordinates (WGS-84 map datum) and a GPS unit, cooperators looked for the polygon on the ground, using the number of dead trees and the size of the polygon (as estimated by the aerial observers) to help characterize the area that the surveyors mapped. They looked for recently killed trees that would have had red or brown needles at the time of the survey in late June. If the polygon could not be found within about ½ mile of the mapped location, they stopped searching.

Once the polygon was located, cooperators walked through the polygon area and determined the cause (or causes) of death for trees with red or brown crowns (some trees may have lost needles since the aerial survey was completed). They did not search for every dead tree in the polygon. They perused the area and estimated the percentage (to the nearest 5 percent) of the dead trees in the polygon that were killed by each agent (usually bear, root disease, or abiotic agents). The completed data forms were sent to ODF in Salem.

Helicopter Sample: Using list sampling, with the probability of selection proportional to the number of dead trees in the polygon as estimated by aerial observers, we randomly selected 55 polygons as candidates for intensive ground sampling (36 in the Coast block and 18 in the Cascade block).

The sample polygons were overlaid onto topographic, road, and ownership GIS layers and printed onto 1:15840 scale maps (1 mile = 4 inches). Using these maps an aerial observer from the original fixed-wing survey then attempted to visit each of the sample polygons in a GPS-equipped helicopter, using the maps and computed polygon center points as guides. Once the location was determined based on maps and dead trees, the pilot hovered near the polygon center, and the observer and pilot each recorded the latitude/longitude of the polygon center and of the nearest road access point. The polygon center was marked from the air by tossing at least two large orange fabric streamers with metal weights attached. This step was taken to facilitate location of the plot by ground crews. The aerial observer also sketched the polygon onto the map, and estimated the size of the polygon in acres and the number of recently killed trees in the polygon. An example of a polygon map appears in the Appendix.

Polygons that were successfully located by helicopter were intensively ground sampled by contract field crews during August and September. Using maps, orange streamers, and GPS data from the helicopter assessments, crews located the approximate center point of each polygon. Trees were sampled by establishing a 5-acre square (466 feet on a side) sampling grid near the approximate polygon center, oriented North/South or East/West to take advantage of topography. The sampling grid consisted of four equally spaced transects, with 132 feet between centerlines. Each transect consisted of two consecutive segments, each 233 feet long. Each transect had two widths. The narrow transect was 16 feet wide (8 feet on either side of center line) and was used for tallying all trees. The wide transect was 66 feet wide (33 feet on either side of the center line) and was used for tallying only dead or damaged trees. Crews recorded tree species, diameter at breast height (nearest 2-inch class), and condition of all trees within 8 feet of either side of the center line. Height and diameter of two site trees were measured on each narrow transect (total of 8 trees per polygon) for each major conifer species. For all other live undamaged trees in the narrow transect, only tree species and diameter were recorded. For all dead and damaged trees

within 33 feet of either side of the center line, the following were recorded: tree species, diameter, tree condition (healthy, live with damage, dead), crown condition (green, yellow, red/brown, or no foliage), and damage agent (up to three). For trees with bear damage, the following were recorded: distance from ground to the bottom and top of bark peeling, the percentage of tree circumference peeled at widest point, and the year in which the peeling occurred. When necessary, the year in which peeling occurred was determined by taking an increment core in the peeled area of the bole and in an adjacent undamaged area and comparing the number of annual rings.

The volume of dead and damaged trees was calculated by determining Tariff numbers for site trees in each polygon, and then estimating volume of the dead or damaged trees from local volume tables generated from the Tariff Program, version 5.0.

All estimates of tree damage were based on the helicopter sample polygons. Because of the small sample

To determine how accurately observers mapped polygons during the fixed wing survey, we calculated the polygon center point (Arc View centroid function) for the fixed wing survey and compared it to the polygon center point determined by the helicopter observer. We assumed that the helicopter observer's GPS point was the "true" location of the polygon center point. We projected a map of both polygons and measured the distance and azimuth from the true location (helicopter) to the fixed wing location.

Results and Discussion: Observers mapped a total of 2,190 polygons. Of these, 355 polygons were coded as mortality in large trees, i.e., not bear damage. These polygons were not considered in the remainder of the project. The remaining 1,835 polygons were attributed to bear damage by the aerial observers. Of these 1,835 polygons, 1,208 occurr ed in the Coast block and 627 in the Cascade block. The observers estimated the total number of recently killed trees in these polygons as 9,913 and 6,623 in the Coast and Cascade blocks, respectively, for a total of 16,536 trees. The location of the area surveyed and the ground verification plots are shown in Figure 3.

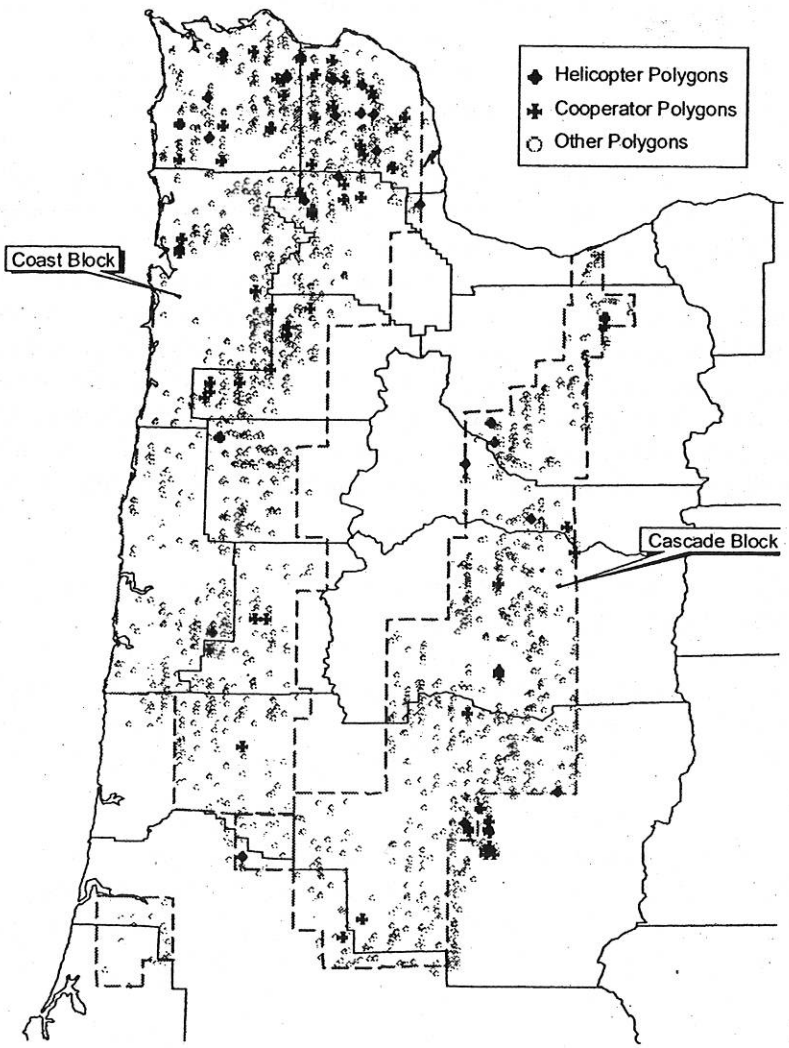

Figure 3. Location of aerial survey and ground verification plots for tree mortality / bear damage in northwest Oregon. The aerial survey was conducted in June 2000.

Selecting and Locating the Sample Polygons: We originally chose 54 polygons for the helicopter sample plots and 150 polygons for the cooperator sample. A major error in translating the digital sketch map data into a GIS data base resulted in many polygons being placed inaccurately on the GIS generated maps. Unfortunately this error was discovered after much of the ground checking had been completed. Once the problem was fixed, we were able to print maps showing the proper location for the polygons, which we then used to d ecide whether or not the corrupted polygons were usable.

We sent maps for 150 sample polygons to cooperators for ground verification. We received no information from cooperators on 14 polygons, i.e., neither maps nor data were returned to us. Cooperators attempted, but were unable, to locate 11 polygons for reasons other than our

computer mishap. The computer error required us to eliminate 46 polygons from the sample because their location was too far from the true polygon location. Cooperators had alrea dy checked many of these polygons. We ended up with 79 usable polygons that were ground - checked by cooperators or ODF field crews. Ground -checking of these plots occurred from July through October. After accounting for the computer error, we estimated th an about 88 percent of polygons in the cooperator sample were drawn accurately enough for ground crews to find them.

For the helicopter sample, 10 of the 54 sample polygons could not be found by the helicopter pilot, even using a GPS. These 10 polygons w ere affected by the computer error, and were placed incorrectly on maps. Because the lat./long coordinates were determined from the map, the helicopter pilot, when arriving at the indicated lat/long location, arrived at precisely the wrong place. One additional polygon was located correctly, but it was discarded because it occurred in a seed orchard, a situation that observers usually do not map. The remaining 43 sample polygons were sampled intensively by contractors. Data from 9 of the measured sample polygons could not be used because of the computer error, leaving 34 useable polygons that were sampled for causes of tree damage. Ground surveys of these polygons took place in August and September. Because of the small sample size we combined the coast and cascades blocks for most of the analyses.

During ground checks of mis-located polygons in both the helicopter sample and the cooperator sample, recently killed trees often were found that apparently were missed by the aerial observers, or that did not have symptoms at the time of the survey flights. It was not possible, however, to use these findings as a sampling of the non -mapped areas because the helicopter observers were seeking areas with recently killed trees. We mention this to emphasize that t he aerial survey provides (for this and other reasons) a very conservative estimate of recent tree mortality and damage.

Accuracy of Polygon Location by Aerial Observers: We were able to assess the accuracy of location for 35 polygons that were not corru pted by the computer error. About half of the polygons were within 0.2 miles of the true location, and 83 percent were within 0.5 miles of the true location (Figure 4). All polygons were within 0.75 miles of the true location.

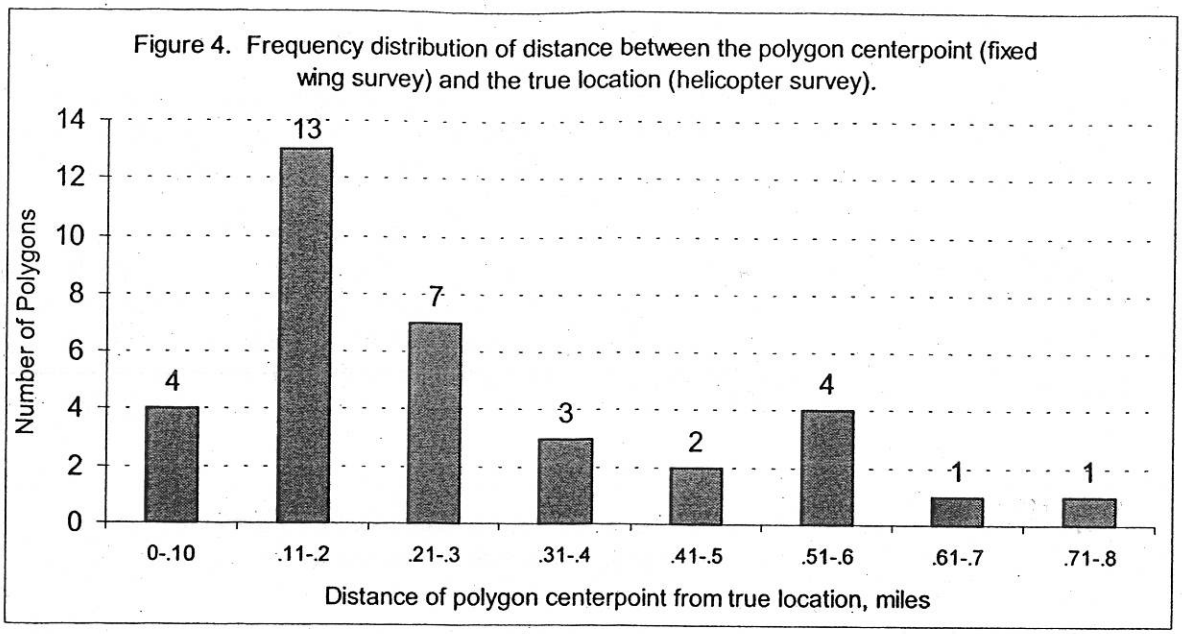

Figure 4. Frequency distribution of distance between the polygon center-point mapped in the fixed wing aerial survey and the true location determined by helicopter survey during the aerial survey for tree mortality in northwest Oregon. The aerial survey was conducted in June 20 00.

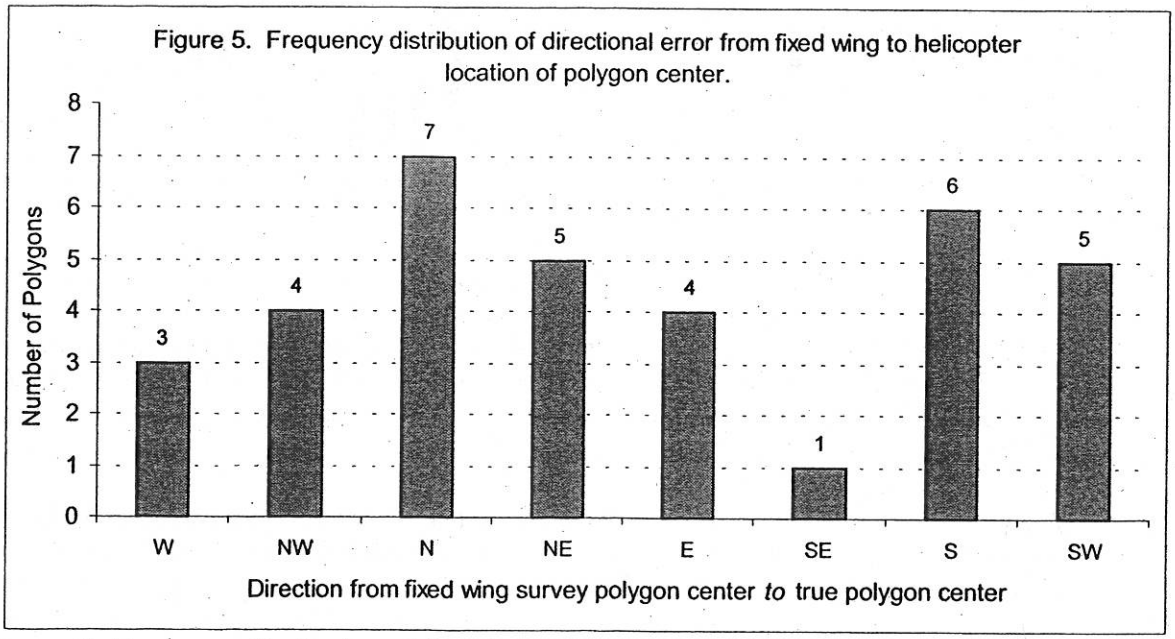

Figure 5. Frequency distribution of directional error between the polygon center-point mapped in the aerial survey and the true location determined by helicopter survey. The azimuth was determined *from* the fixed wing location *to* the true (helicopter) location. The aerial survey was conducted in June 2000.

Although there was no clear pattern to the direction of the mapping errors, polygons tended to be mapped incorrectly in a north-south direction more frequently than in an east-west direction (Figure 5). There was no apparent correlation between the magnitude of the distance error and

the directional error. Because the fixed-wing aircraft generally followed lines along a north -south axis, the data suggest that it may be more difficult for observers to accurately sketch distances parallel to the flight line rather than perpendicular to it.

Comparison of Polygon Size and Area for the Helicopter and Fixed Wing Surveys of the Same Polygons: The mean number of observed dead trees in the helicopter and fixed wing surveys for the 34 sample polygons was 23.2 and 18.4, respectively. These means were not significantly different (T-test, .05 significance level). However, in most cases the observers tended to record fewer recently killed trees in the helicop ter survey than in the fixed-wing aircraft survey (Figure 6).

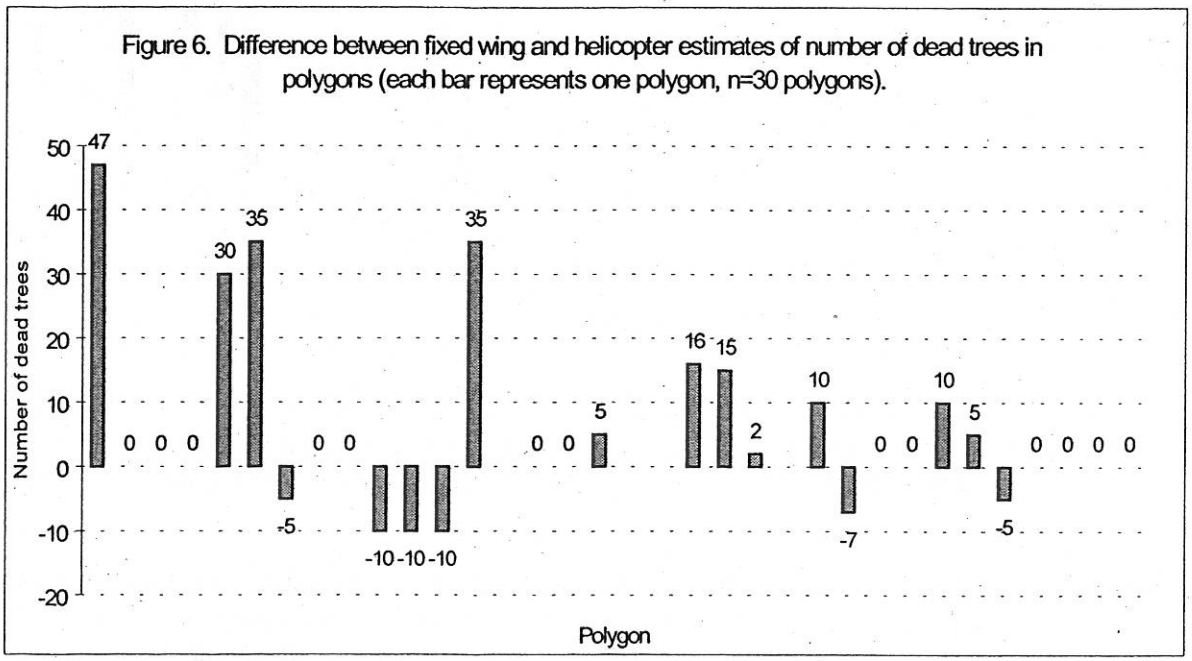

Figure 6. Difference between the fixed wing survey and the helicopter survey in the estimate of the number of dead trees in polygons. A positive number indicates that the fixed wing survey estimated more dead trees than the helicopter survey. The aerial survey was conducted in June 2000.

The mean estimated area (in acres) of the sample polygons also did not differ significantly (T - test, .05 significance level) between the helicopter and fix ed wing surveys. The observer tended to draw the polygons smaller when surveying from the helicopter than when surveying from the fixed wing aircraft (figure 7).

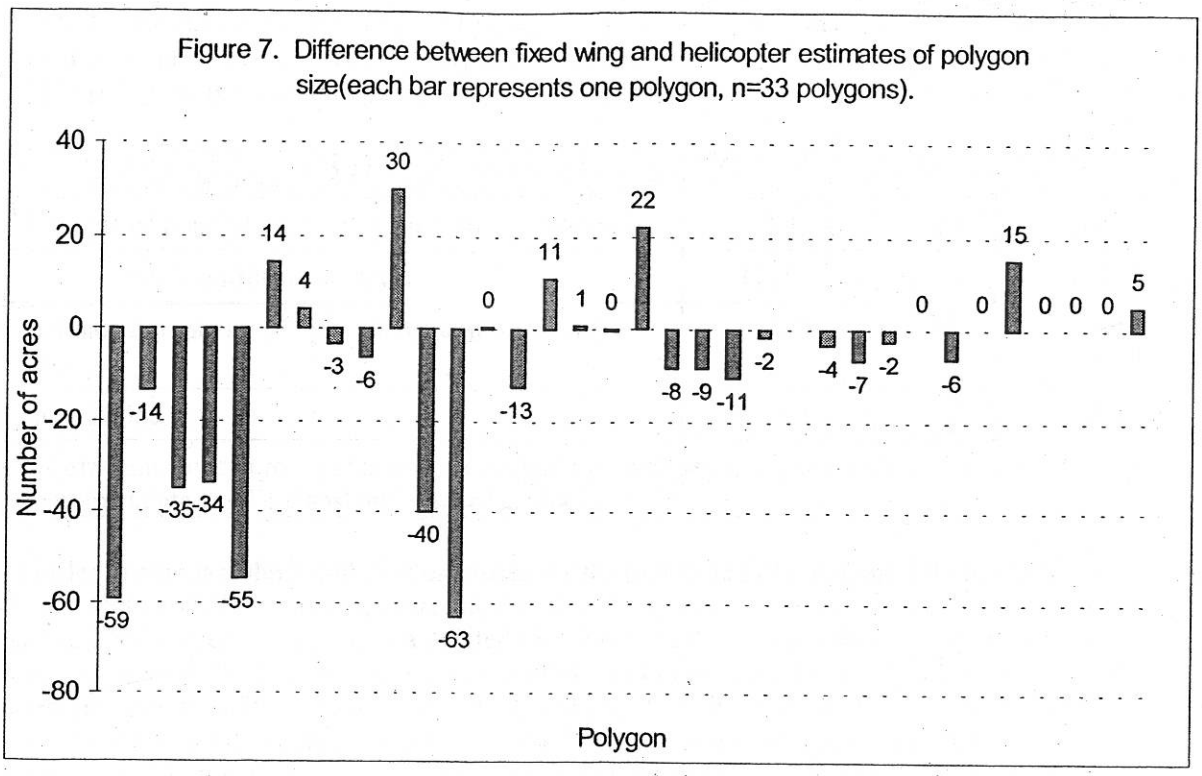

Figure 7. Difference between the fixed wing survey and the helicopter survey in the e stimate of the area of polygons (in acres). A positive number indicates that the fixed wing survey estimated more acres than the helicopter survey. The aerial survey was conducted in June 2000.

Number and Proportion of Sample Polygons with Bear Damage: The aerial observers coded 1,835 polygons as having bear damage, but only a portion of these actually contained trees damaged by bears. Of the 113 polygons that were ground-checked, 74 (65 percent) contained trees damaged by bears. The proportion of samp le polygons with bear damage was slightly greater in the Cascade block (71 percent) than in the Coast block (64 percent)(Table3).

Estimate of the Population Proportion of Polygons with Bear Damage: Because sample size was reduced by the data translation error, we combined the cooperator and helicopter samples. This is reasonable since both samples were drawn independently and with replacement. The estimated proportion of all polygons in the 2000 survey that have bear damage is 0.42 (Table 1). This proportion is lower than the simple proportion calculated for the *sample* polygons because most of the polygons mapped by observers were very small (in terms of number of recently killed trees), and these small polygons are less likely to have bear damage than larger ones.

Table 1. Estimate of the proportion of polygons in the survey area that contain trees with bear damage, aerial survey for tree mortality in 2000, northwest Oregon. Based on ground verification of 113 polygons (cooperator and helicopter samples combined), July-September 2000.

Polygons	Coast	Cascades	Total*
Estimate of population proportion with bear damage	0.47	0.28	0.42
95% Confidence interval	.37-.57	.16-.40	.34-.50
Estimated number with bear damage in the survey area	565	175	739
Sample size, n	83	30	113
*Horizontal sums across columns to not equal the total because totals are calculated from the combined data for the Coast and Cascades blocks.			

In order to compare the population estimates for the proportion of polygons with bear damage for the 1989 and 2000 surveys, we recalculated the 1989 estimates using the methods described for the 2000 survey. When we recalculated the 1989 data the estimate for the proportion with bear damage was 0.71 for the coast and cascades blocks combined (Table 2), which is not much different than the 0.76 estimated without adjustment for probability of selection. Even given the questionable basis for comparison between the 1989 and 2000 surveys, the data suggest that the proportion of polygons that have bear damage was substantially less in the 2000 survey than in the 1989 survey. These data are consistent with the results from a limited ground verification conducted in 1999 (Oregon Department of Forestry, unpublished data).

Table 2. Estimate of the proportion of polygons in the survey area that contain trees with bear damage for the aerial survey for tree mortality conducted in 1989, northwest Oregon. Based on ground verification of 147 polygons.

Polygons	Coast	Cascades	Total*
Estimate of population proportion with bear damage	0.71	0.66	0.71
95% Confidence interval	0.63-.79	0.51-.80	0.64-.78
Estimated number with bear damage in the survey area	1,241	243	1,492
Sample size, n	123	24	147
*Horizontal sums across columns to not equal the total because totals are calculated from the combined data for the Coast and Cascades blocks.			

Several factors could explain some of the apparent differences between the 1988-89 and 2000 survey results. In the 2000 survey, polygon size was the number of dead trees in the polygon as seen by the aerial observers, and ranged from 1 to 300 trees/polygon. In the 1988 and 1989 surveys, the index of size was an estimate of the relative mapped area of the polygons ranging from 1 to 32 for the smallest to largest polygons, respectively. The difference in the range of polygon "sizes" between the 1989 and 2000 surveys becomes significant when expanding from the sample polygons to population estimates, and injects some doubt into the comparisons.

The 1989 sample was stratified to select equal numbers of thinned and unthinned stands. Because bear damage tends to occur more frequently in thinned stands, this could have skewed the overall mean in favor of a higher frequency of damage.

Another source of bias arises from the fact that in 1989 we limited our polygon population to those 1,451 that occurred on cooperator lands, out of a possible 2,109 polygons mapped in the overall survey. Most state and industrial lands were included in the 1989 survey, but much federal and small private ownership was excluded. The latter probably were less likely to have bear damage than state or industrial lands, which could have biased the 1989 survey in favor of polygons with a high probability of bear damage.

Weather can affect the time and rate of symptom development in a given year, causing bear damaged trees to be more or less visible at the time of the survey. Also, forest management practices and bear damage control measures have been in place in many areas, and could have reduced the amount of bear damage since the ground verification project of 1989.

Equally important may be Swiss needle cast, which has become epidemic in many parts of the Coast range since the 1988 and 1989 surveys. Swiss needle cast causes foliage loss which results in decrepit, poorly growing trees that apparently are not desirable food for bear.

Finally, the 2000 survey area was almost one million acres larger than the 1989 survey area, and much of this increase was in the northern part of the Cascades, an area, which was not surveyed in 1988 or 1989.

Estimate of the Population Proportion and Area of Polygons with Damage by Various Agents: From the 113 polygons that were ground-checked, root disease was the most common damage agent found. We estimate that 63 percent of the entire population of polygons contain trees killed by root disease, 42 percent contain trees damaged by bear, and 43 percent contain trees damaged by other agents. We estimate that root disease or bear damage, singly or in combination, occur in 89 percent of the polygons (Table 3).

Table 3. Estimate of the proportion of, and area represent by, polygons in the survey area that contain trees with damage by various agents for the aerial survey for tree mortality, 2000, northwest Oregon. Based on ground verification of 113 polygons (cooperator and helicopter samples combined), July-September 2000.

Damage Agent	Proportion	Area (acres)
Bear	0.42	19,369
Root Disease	0.63	18,946
Other Agents	0.43	14,120
Bear and/or Root Disease	0.89	29,090

Relationship Between the Occurrence of Bear Damage and Polygon Size (Number of Trees) or Area (Acres): As in previous surveys, larger polygons, either in terms of area (acres) or number of dead trees were more likely to have bear damage than smaller ones (figures 8 and 9). The mean size of polygons with bear damage was 50 acres, compared to 27 acres for polygons

without bear damage. Polygons mapped by observers as having 50 or more recently killed trees always had bear as the primary cause of tree damage.

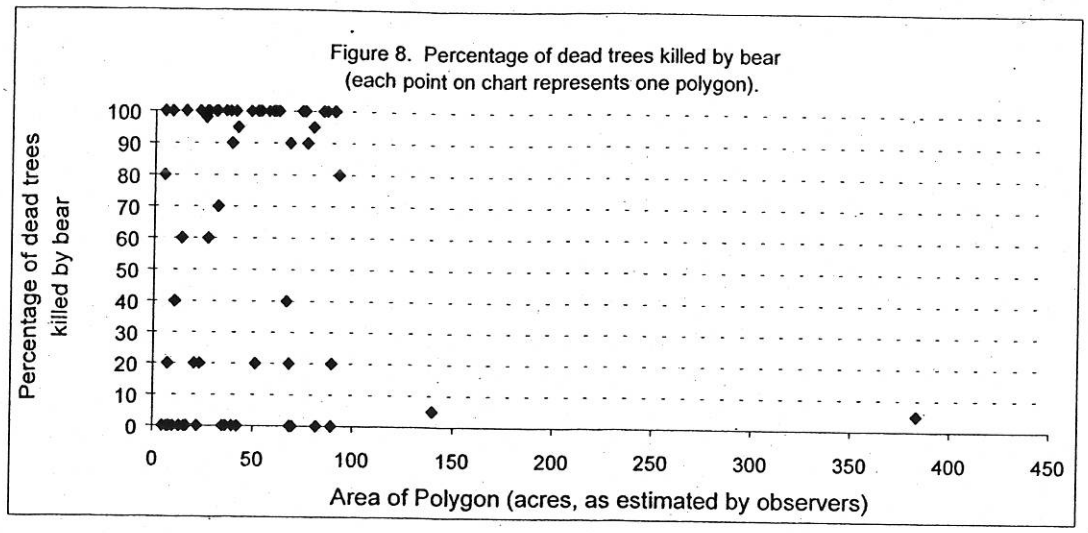

Figure 8. Percentage of dead trees that were killed by bears in relation to the number of dead trees in the polygon (as recorded by aerial observers). The aerial survey was conducted in June 2000.

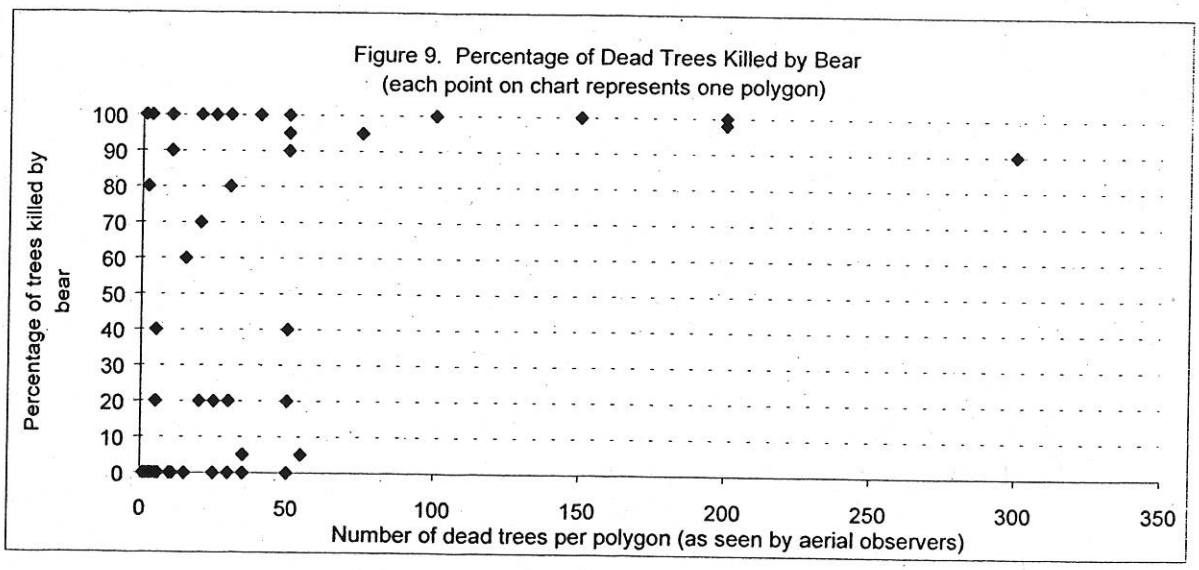

Figure 9. Percentage of dead trees that were killed by bears, in relation to the number of area of the polygon (as recorded by aerial observers). The aerial survey was conducted in June 2000.

PORT-ORFORD CEDAR ROOT DISEASE SURVEY

Port-Orford-cedar (POC) (*Chamaecyparis lawsoniana*) is highly susceptible to the introduced root pathogen, *Phytophthora lateralis*. *P.lateralis* causes a fatal root disease that affects POC on wet sites throughout most of its range in southwest Oregon and northern California.

Various aerial surveys have been used to estimate the distribution of the disease. However, very little ground verification of these surveys has been done. Usually it is assumed that all dead POC are those killed by *P. lateralis*. However, damage to POC caused by black bears feeding on the bark can give the same aerial signature as root disease.

Objectives: 1) to determine the relative frequency of mortality caused by POC root disease, black bears, or other agents, and 2) to describe the accuracy of aerial sketch mapping from a fixed wing aircraft.

Methods: POC mortality was mapped during 1998 in two aerial surveys. The aerial observers drew a figure on the map (called a polygon) showing the area in which recent mortality occurred and indicated the number of dead trees in that area. The sketch maps were digitized into a GIS. In 1999 we randomly chose 55 polygons from the 1998 surveys for ground verification. The latitude and longitude of the centroid of each chosen polygon was determined on the GIS and loaded into a hand-held GPS unit. Using the GPS unit, the ground crew went to the place that corresponded with the polygon centroid. From this point they searched for the dead trees described by the aerial observers. If they could not find them within approximately one quarter mile of the centroid, they considered the accuracy to be unacceptable. If they found dead trees of the number and pattern of distribution indicated on the map, they walked to the apparent center of the polygon and determined latitude and longitude with the GPS. The polygon was then searched for all trees that would have appeared as recent mortality in the 1998 aerial surveys. Tree species and cause of death were determined for all trees that had been dead for 3 years or less.

Results and Discussion: Of the 55 polygons checked, 36 (65%) were accurately drawn on the map and could be found by field crews, and 19 (35%) were not accurately drawn (they could not be found within about one quarter mile of the supposed location). Of the 36 accurately drawn polygons, 90 percent were within 1/4 mile of the "true" location.

Of the 36 accurately drawn polygons, 21 (58%) percent had mortality caused by *P.lateralis* only, 8 (22%) had mortality caused by *P.lateralis* and black bear, and 7 (20%) did not have Port-Orford cedar present (dead Douglas-fir was present, apparently mis-identified by the observers). On average 8 out of every 10 polygons sampled contained some mortality caused by *P. lateralis*, and all of the polygons sampled with dead Port-orford cedar contained POC root disease. Port-Orford-cedar with bear damage, but not root disease, was observed by field crews outside of sample polygons.

Accurately drawing a sketch map of patches of dead trees in a fixed-wing aircraft moving in excess of 100 miles per hour is a difficult task. The fact that one out of three polygons could not be found by ground crews is not as troubling as it might seem. This type of aerial survey is by definition coarse, and precise location of polygons is not as important as the total number and general distribution of them. Considering the low cost of the aerial survey (less than ½ cent per acre), correctly identifying POC root disease 80 percent of the time might be acceptable. When greater accuracy of location of each polygon is required, a helicopter might be better suited to the task than a fixed-wing aircraft.

SUDDEN OAK DEATH SURVEY

Sudden Oak death, caused by the non-native pathogen *Phytophthora ramorum*, has been epidemic in nine California counties around San Francisco for several years. As of early J uly 2001, the disease had not been found in Oregon or near its southern border.

Objectives: To detect and accurately locate all occurrences of Sudden Oak death in Southwest Oregon.

Methods: In late July, 2001 we conducted a fixed-wing aerial survey of southwestern Oregon from Gold beach south to the California border and inland approximately 40 miles. Observers looked for dead overstory tanoak as an indicator of possible SOD.
A follow-up helicopter flight was commissioned to accurately determine the l atitude and longitude of each potential SOD site identified in the fixed -wing survey.

Each potential SOD site was visited by field crews in August 2001. Tissue samples from symptomatic tanoak and other hosts of *P. ramorum* were collected and plated onto *Phytophthora*-selective culture media in the field. Soil samples were collected from most of the sites. Plates were read and samples further analyzed at Oregon State University using PCR and ELISA tests.

Results and discussion: The fixed-wing aerial survey identified 23 potential SOD sites. Two of these 23 sites did not have dead tanoak or other species susceptible to *P. ramorum*. At these two sites, red alder and ocean spray were present and appeared similar to dead tanoak. In July, the dead flowers of Ocean spray (*spirea sp.*) can give an aerial signature similar to that of small dead tanoak. Recently killed red alder also appears similar to dead tanoak.

All of the 21 remaining sites had dead tanoak present. Five of these sites were confirmed posit ive *for P.ramorum.* Other causes of tanoak mortality included *Armillaria* sp. (7 sites), intentional herbicide (2 sites), mechanical damage (2 sites), and unknown agents (5 sites, some sites yielded and unidentified *Phytophthora* species). *Armillaria* was the most frequently encountered pathogen associated with dead tanoak, and typically occurred on single trees or clumps of 2 or 3 trees. Sudden oak death patches ranged from one or two symptomatic trees to over 50 trees, and varied in area from 1/2 -acre to 15 acres.

During the ground-verification and sampling, a few additional symptomatic tanoak trees were noticed that apparently were missed by the aerial observers, or that became symptomatic after the aerial survey was completed. Aerial photo flights in late august and September revealed additional symptomatic tanoaks, indicating that symptoms continue to develop through late summer and fall. Additional surveys are required to fully describe the extent of SOD in Oregon.

Detection of a non-native pathogen in Oregon triggers a number of regulatory actions by the State Department of Agriculture, including quarantine and eradication actions. For this reason, all symptomatic trees identified from surveys must be ground -sampled to confirm presence of the pathogen. Our experience in the field suggested that it would have been difficult, if not impossible, to find many of the sites without the helicopter GPS points.

Although the aerial survey detected the first occurrence of SOD in Oregon, it may not have detected all of it. Recent research has shown that many hosts of *P. ramorum* can be infected without dying or without producing symptoms visible from the air. It follows that it would be inappropriate to interpret the aerial survey results as describing *all* SOD locations in Oregon. Clearly, surveys are a necessary compliment to aerial surveys for SOD.

CONCLUSIONS

Fixed-wing aerial sketch-map surveys remain one of the most economical tools for broad area assessments of damage to forests. With trained and skill ed observers, the fixed -wing surveys are sufficiently accurate for most types of damage. When the aerial signature is not unique to a specific disorder, ground-sampling is essential. When the precise location of small polygons is necessary for sampling purposes (such as the SOD or bear surveys) a follow -up helicopter flight is recommended to verify the fixed wing data and to improve the efficiency of the ground - verification.

ACKNOWLEDGEMENT

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Brennan Ferguson and Mike McWilliams

Multi-Scale Data to Assess and Monitor Sudden Oak Death

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The USDA Forest Service (FS) and California Department of Forestry and Fire Protection (CDF) are monitoring Sudden Oak Death (SOD) under the umbrella of the larger California Land Cover Mapping and Monitoring Program (LCMMP). The LCMMP is a statewi de cooperative effort among the FS and CDF focused on mapping and monitoring California's vegetation and land cover.

Under the LCMMP the FS and CDF conduct change detection as a basis for monitoring and for identifying land cover change across all owner ships. This program has successfully used satellite imagery and change detection techniques to map and monitor changes in vegetation due to drought-induced insect mortality, fire mortality and subtle changes due to selective harvest methods. The current project has been easily adapted under the larger program to identify oak mortality, potential SOD areas and develop a basis for establishing a monitoring program for SOD.

The distribution of SOD in California might stretch from the Oregon border to Mon terey County, however, to date there are 10 counties confirmed with SOD. These 10 counties are included in the project area that spans Humboldt County in the north to Monterey County in the south.

The objective of the SOD project is to use multi -scale remotely sensed data to identify "hot spots" of oak mortality, and verify these areas with a combination of airborne imagery, aerial surveys and field verification. Given the size of the affected land area, detection and monitoring SOD would not be practical without the use of remotely sensed data.

Landsat Thematic Mapper (TM) satellite imagery was acquired for two time periods, July 1994 and May 2000, to detect changes in oaks and develop a base from which to identify and map oak mortality. Land cover changes are derived from the TM imagery, employing a multi -temporal Kauth –Thomas transformation. This process produces three components, a greenness component, brightness component and wetness component. These components portray subtle differences in land cover. If a group of trees experienced mortality during the 1994 and 2000 timeframe it would be indicated in the levels of greenness, brightness and wetness, possibly less wet and green, and more bright. Vegetation data is used to stratify the brigh tness, greenness, wetness image into lifeform and change. Unsupervised image classification is performed and each resultant class is placed into a particular change class, according to its level of change.

Areas depicting large decreases in change were evaluated with existing fire history and stand history data. Areas of small decrease were further evaluated to determine the potential for change due to oak mortality. Vegetation layers, spectral reflectance values, comparison to aerial imagery from known SOD affected areas, and other ancillary data were used to assist in this labeling process. If mortality due to SOD was suspected, the class was then labeled as potential SOD. Because of the possibility that areas of potential SOD might be eliminated during an aggregation

process this particular class has been left at the pixel level. Additional remotely sensed data of various scales including two-meter digital camera imagery were acquired from flights over affected counties and adjacent areas. Digital camera data in conjunction with the satellite imagery were analyzed to identify the extent of oak mortality. Each photo was examined for signs of hardwood mortality that could not be attributed to known cause. Areas of potential SOD were compared to the digital camera data for further confirmation of mortality. In areas of confirmed SOD the digital camera data provided a valuable reference tool and allowed for a more detailed assessment of both the visual appearance of SOD, as well as the extent of the mortality. As a final step in the validation process an accuracy assessment will be performed.

Aerial surveys provide another means for detection, monitoring and calibration, and discrimination of various spectral reflectance values important to image classification. The surveys were conducted from a fixed-wing aircraft over a period of three days using a crew of two and a pilot. Approximately 10 million acres of California's coastal hardwood rangelands and mixed hardwoods were surveyed. Mortality ar eas were identified visually, sketch mapped, and photographed on 35mm color film. A handheld Global Position System (GPS) was used on the aircraft to record the flight line and pinpoint potential SOD sites. The GPS line and point data were exported to aid in creating a GIS coverage of mortality areas. The combination of GPS, photography, and detailed notes were used to map and characterize potential areas of mortality. Field verification is currently being performed to confirm or refute presence of the disease and evaluate the accuracy of the survey and change data.

This collaborative effort is essential to a low-cost, long-term monitoring and sampling strategy for SOD. These data are prerequisite for identifying future management opportunities that include allowing for more focused field efforts, acquiring future data more efficiently and providing a critical look at current SOD related mortality conditions. The resultant maps will provide a baseline for future monitoring efforts and may streamline field confirmation of areas affected by SOD.

MaryLou Fairweather and Sally Campbell

SPECIAL PAPERS

Moderator: Mike McWilliams, Oregon Department of Forestry, Salem

Pitch canker: Testing the ecological limits in California

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Pitch canker, caused by *Fusarium circinatum*, was discovered in California in 1986 (McCain, et al., 1987). Since that time the disease has become more widespread in coastal California, where it has caused considerable damage to Monterey pine (*Pinus radiata*), in both urban and native forests. Insect associates of Monterey pine, including twig beetles (*Pityophthorus* spp.), engraver beetles (*Ips* spp.) and the cone beetle (*Conophthorus radiatae*), provide wounds that serve as infection courts for *F. circinatum* (Fox, et al., 1991; Hoover, et al., 1996). Most of these insects feed on multiple pine species, many of which are also susceptible to pitch canker. The wide host range of the pathogen and its insect vectors suggest a considerable potential for more extensive damage to coniferous forests in the western U.S.

Whereas efforts to minimize the spread of pitch canker are worthwhile, it is likely this will only delay the eventual arrival and establishment of the disease in all areas where susceptible hosts are found in a suitable environment. The ultimate ecological limits on the disease will be imposed by any of the following three factors: 1) availability of insect vectors/wounding agents, 2) availability of susceptible hosts, or 3) environmental conditions. Because insects capable of vectoring pitch canker are geographically widespread and many have wide host ranges, they appear unlikely to limit expansion of the pitch canker infestation. On the other hand, both host availability and environmental factors are likely to impose limitations under some circumstance.

Based on observations in urban plots of Monterey pine, about 2% of the trees sustained no infections and thus appeared likely to be resistant to pitch canker (Storer et al., 2001). Inoculation studies confirmed that some proportion of the trees in any given stand, whether native or planted, will manifest resistance to pitch canker (Storer et al., 1999). Variation in susceptibility appears to be the case for other species as well (Clark, 1999). Consequently, in native stands, selection may enrich populations for resistant individuals, allowing the forest to adapt to the new pathogen.

Measures of inherent genetic resistance may actually overestimate the eventual damage that will be caused by pitch canker. Experiments using clonally propagated Monterey pine have documented that prior inoculation can significantly enhance resistance to subsequent challenge with the pitch canker pathogen (Bonello, et al., 2001). Observations from permanent plots suggest that this induced resistance may be operative under field conditions. Specifically, some trees that were severely diseased in 1996 were free of disease in 1999. We hypothesize that their recovery reflected systemic induced resistance resulting from previous exposure to the pathogen. If this phenomenon is widespread, it may impose a significant limitation on the development of pitch canker.

The extensive development of pitch canker on the central California coast clearly shows that this environment is conducive to disease development. However, observations from permanent plots on the Monterey Peninsula suggest that even within this coastal region, environmental variation may influence the progress of disease. In particular, plots located within one mile of the coast had more severe disease and a faster rate of disease increase than plots located farther inland. This may reflect an effect of the frequency and duration of foggy periods and the associated condensation. Experiments in controlled environment chambers indicate that insect wounding may be superficial and thus infections may succeed only where ambient moisture is available. If so, climatic limitations may slow, and possibly prevent, the movement of pitch canker into more arid inland areas of California. Also, because *F. circinatum* shows relatively little growth below 9 C, establishment of the pathogen in more northerly latitudes and at higher elevations is likely to be limited.

In summary, whereas pitch canker may well expand into uninfested-forested regions in the western U.S., the ultimate impact is likely to be constrained by host resistance, both inherent and induced, and environmental limitations on the infection process.

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Wildlife Tree Studies on Industrial Forest Lands of Washington and Oregon

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Background: Harvest practices over the past 100-years have changed the structure and complexity of managed forests. This has lead to a reduction in the frequency of some butt-rot and bole decay fungi, and with fire suppression a similar decline in those species associated with fire, such as *Phaeolus schweinitzii* and *Laetiporus sulphureus*. Likewise, felling and even age management effectively reduces defect and decay organisms such as *Phellinus pini*, dwarf mistletoe, and *Echinodontium* etc.). Snag density and quality has also diminished as a consequence of harvest activities, stand conversion (hardwood to conifer etc.) machine operability and out of concern for worker safety. Therefore it is prudent to determine if snag features can be detected and mapped prior to harvest or created during harvest activities. What science is needed to demonstrate that snag/green tree programs provide for cavity-dwelling wildlife? Science can help with this question by addressing the following topic areas:
WHAT – what kind of snags/green trees are to be left, what dimensions/characteristics should they have, what happens to them over time.
NUMBER – how many to leave; single trees; groups?
WHERE – how to locate and where are they located, at what distribution.
USE – who uses them, when, is it enough? Two ongoing studies are reviewed concerning this topic area: (1) Aerial survey for snag rich habitat and (2) Snag creation study.

Aerial Survey for Snag Rich Habitat

An area of the Weyerhaeuser Longview Tree Farm in Washington State was flown by Northwest Aerial Reconnaissance for detection of mortality on a landscape and stand basis. Two WA study areas were chosen as the test site: Yacolt (1075 acres) and Silver Lake (1380 acres). The objective was to evaluate detection and location capabilities for tree mortality within a variety of stand ages from 15-70 years.

Root-rot caused by *Phellinus weirii* and *Armillaria ostoyae* was the dominant mortality agent on the landscape (67%-72% of all centers). Some 200 snags were investigated in the larger landscape study, with many being too small to support cavity nests. In 1999, 39 discrete root-rot or other mortality centers were ground verified for snag characteristics, gap size, under-story plant composition, mortality agent and the presence or absence of cavity nests. The average mortality tree supporting one or more cavity nests was 40 cm dbh, and greater than 33 years old at death. Aerial detection was found to be 90+% accurate for detection of visible snag crowns. Snags near the forest edge (i.e. adjacent to clear-cut or younger stand) appeared to have a greater probability of usage. Numerous small bird nests (possibly Pacific Slope Flycatcher) were found on the upper part of root-wads of wind-thrown and butt rotted trees.

Aerial mortality mapping combined with GIS and other stand data analysis (age, volume, species) appears to provide alternative means of finding and then managing wildlife resources such as cavity nesting birds.

Snag Creation Study

In 1997, a study was designed and initiated to test the effectiveness of creating snags by topping trees with mechanical harvesters in clear-cut harvest settings. The goals for creating snags are to: accelerate the establishment of snag habitat; improve distribution across the landscape; and create snags that are operationally safe and practicable. A study site was established on Weyerhaeuser Company Oregon timberlands in the Eugene/Springfield and Cottage Grove areas.

Snags were created by cutting the tops of living harvest trees using a feller-buncher. In all, 1,117 snags were created with an average dbh of 20 cm (7-40 cm dbh) and height of 21 feet (12-33 feet). Snags were created in-groups or as single units.

Much of the data is still preliminary with several additional years needed to truly validate the study findings. Each year snags are evaluated to (a) quantify quality characteristics of created snags in sample harvest units (b) evaluate decay dynamics and persistence of created snags, (c) quantify use of created snags by cavity nesting birds, (d) model habitat relationships and probability of use of created snags within and among treatments being used by cavity-nesting birds, and (e) develop recommendations for applying snag topping prescriptions based on empirical habitat models.

The results to date show: (1) several created snags already have received use by various species of wildlife, particularly woodpeckers and raptors (e.g., red-tailed hawk), (2) woodpecker foraging was documented on 50% (558 of 1,117 snags) of the created snags. One to nine woodpecker nest cavities were documented on 21 different trees within 14 different settings; 7 of these cavities occurred in created snags within single-high treatments, (3) woodpecker foraging and flaking activity was observed on created snags that occurred in all 6 different treatments, (4) observations of wildlife species using created snags for perching and foraging include the American robin, hairy woodpecker, northern flicker, red-tailed hawk, Stellar's jay, Swainson's thrush, and turkey vulture. Additionally, raptor pellets (regurgitated bone, hair and/or feathers by a hawk or owl) have been discovered at the base of some created snags, and (5) In 2000, day-roosting bats (species unknown) were observed on 3 different occasions under exfoliating bark on 3 different created snags. Decay fungi present in this early phase include; *Phellinus pini* and *Phellinus hartigii* (limb and bole infections these were among the first to be exploited by cavity nesters), while early succession decay fungi predominate in other created snags, including; *Cryptoporus volvatus, Gleophyllum sepiarium, Schizophyllum commune, Trichaptum abietinus*, and *Coriolus versicolor.*

SPECIAL PAPERS

Moderator: MaryLou Fairweather, USDA Forest Service, Flagstaff, AZ

Oak Decline and Ecosystem Health in Eastern Hardwood Forests

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Hardwoods dominate forest cover in the thirteen states of the southern region, with about two-thirds of the area in upland hardwood, bottomland hardwood, or oak-pine mixtures. Upland hardwood is by far the largest component covering about 37 percent of the area (Sheffield and Dickson 1998). Because of land use history (e.g. woods grazing, widespread wildfire, exploitive logging for wood products) and the decimation of American chestnut by the introduced chestnut blight fungus, oaks probably represent a larger component of the ecosystem today than at any time in the past. These events, coupled with fire control and low harvest levels over the past 60-80 years have resulted in forests that are most certainly very different in composition, structure, and diversity than the forests that existed prior to European settlement.

Oak species are economically and ecologically important in the southern region as valuable timber species and indispensable habitat components for wildlife feeding on hard mast. However, oak decline is a widely distributed change agent that is altering species composition and forest structure in upland hardwood and mixed oak-pine forests of the region. Oak decline in upland hardwood and mixed oak-pine forests is a disease complex resulting from the interaction of three groups of factors as described by Manion (1991). Physiologic age, soil depth and texture, and oak species composition and density are the main long-term predisposing factors. Common inciting factors include prolonged acute drought, spring defoliating insects like fall cankerworm and gypsy moth, and late spring frost. The biotic agents most often identified as contributing factors include Armillaria root disease and insect pests of opportunity like twolined chestnut borer and red oak borer.

The diagnostic symptoms separating oak decline from other diseases of oak are slow, progressive dieback from the top downward and the outside inward in upper canopy trees (i.e. dominants and codominants). It results from a disturbed carbohydrate physiology and water relations when mature trees become stressed and subject to root disease (Wargo and others 1983, Manion 1991, Hyink and Zedaker 1987). The time scale of disease progression is measured in decades rather than months or years. The introduction of the gypsy moth into northern parts of the region has exacerbated and accelerated oak decline there because oaks are preferred gypsy moth hosts and spring defoliation contributes to changes in stored carbohydrate reserves that increase root disease susceptibility. While disease development may take decades from inception to visible dieback symptom expression, susceptible trees die within a few years of the time when dieback exceeds one-third of the crown volume. Not all affected trees reach this point. Those with slight levels of dieback often recover from visible crown symptoms (Oak unpublished[1]).

[1]*Data on file at U.S.D.A. Forest Service, Southern Region Forest Health Protection, Asheville, NC Field Office, P.O. Box 2680, Asheville, NC 28802*

Species in the red oak group are most susceptible (particularly black and scarlet oaks), with hickories being the only non-oak species group commonly observed with symptoms in decline areas (Starkey and others 1989). Like all native diseases and insects, oak decline is a part of natural ecosystem processes that have always affected some component parts of the forest landscape. The unprecedented amount of oak and the absent American chestnut distinguishes the current decline situation in terms of the ecosystem impacts from those that have occurred in the past.

Oak decline is not a new phenomenon. Forest workers have reported occurrences since the mid 1800's (Beal 1926, Balch 1927) and in every decade since the 1950's (Millers and others 1990). In fact, oak decline may be more common and severe since the 1950's due to the predisposing action of extreme regional drought early in that decade on a cohort of trees susceptible at that time (Tainter and others 1990, Dwyer and others 1995). An apparent increase in incidence and severity in the early 1980's led to an intensification of survey and monitoring activities (Starkey and others 1989, Starkey and others 1992, Oak and others 1991), and, more recently, efforts to develop risk-rating systems to aid management decision-making (Oak and Croll 1995, Oak and others 1996, Oak and Courter 2000). Severe oak decline episodes continue to occur in the region where predisposing conditions, inciting events, and contributing factors are coincident, such as occurred in Arkansas in 1996 and 1999-2001 (Starkey and others 2000).

Not all oak forests are equally affected by oak decline. Analyses have shown differences among states with Virginia, North Carolina, and Tennessee having the highest incidence. Among physiographic subregions, the Southern Appalachian and Ozark-Ouachita Mountains have the highest incidence. Most of the decline-affected area is on privately owned land because a large percentage of the total host type area is in this ownership class. However, public lands (especially national forests) have by far the highest incidence among ownership classes. The reason for this disparity in incidence is that national forest lands in heavily affected areas have a higher frequency of attributes that are important in oak decline etiology. These are predominantly oak species composition, advanced physiologic age, and average to low site productivity (Oak and others 1991, Oak and others 1996).

Oaks will not be eliminated from oak decline-affected areas, but they are being reduced in number and diversity. This is due to a lack of competitive oaks in lower crown positions to replace those that die. Red maple, black gum, and other relatively shade tolerant species are increasing instead, and are the trees most commonly replacing dead and dying oaks (Anderson and Cost, unpublished data[2]). This change has several effects on ecosystem structure and function. Structure becomes more complex as canopy density is reduced and the number of small openings increases. The quantity of dead standing trees and down woody debris increases denning and foraging sites for some animals, but perhaps more than can be effectively exploited. Overall susceptibility to decline and gypsy moth defoliation is reduced due to a smaller oak component. Hard mast

[2]*Data on file at U.S.D.A. Forest Service, Southern Region Forest Health Protection, Asheville, NC Field Office, P.O. Box 2680, Asheville, NC 28802*

production potential, already severely impacted after chestnut blight, is further reduced in quantity, quality, and diversity as the numbers of oaks go down and species in the red oak group suffer greater impacts than those in the white oak group (Gysel 1957, Oak and others 1988).

Possible responses to oak decline range from doing nothing to altering forest composition and structure to maintain oak abundance and diversity through silviculture. The choice of no action implies that the forest that is developing (more complex structure, low susceptibility to subsequent oak decline events, fewer oaks overall, less diverse mixture of oak species) is more desirable than one that could be managed for similar structural attributes, more oak, more diverse oak composition, higher mast production potential, and somewhat higher susceptibility to both gypsy moth and oak decline risk. The selection of options along this continuum depends on the relative importance placed on oak and the cost of treatments. High importance would indicate active measures to maintain oak through timber harvest and other disturbance (e.g., fire) in such a way as to introduce age class, structural, and biological diversity (including all available and ecologically adapted oak species) on the landscape. Portions of the landscape would always be vulnerable and affected, but a relatively uniform, vulnerable condition overall could be avoided.

The relative importance of oak is both a biological question and a social one, but the cumulative impact of the loss of American chestnut, continued oak decline, and gypsy moth indicate that intentional efforts should be taken to insure that oaks are maintained at some level.

Research needed to inform these questions includes the role of oak in maintaining wildlife habitat, especially for animals that depend on acorns for food such as black bear; in maintaining biodiversity; in local economies; and the effects of management practices on oak regeneration in interaction with oak decline. Further, projections based on modeling would be helpful for evaluating the consequences of various alternatives at a landscape scale. Risk rating models have been developed as first steps towards identifying areas with greatest present and potential risk and impact (Oak and Croll 1995, Oak and others 1996, Oak and Courter 2000).

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Carbon and Nitrogen Nutrition of the Canker Fungus *Nattrassia mangiferae*

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Introduction

The canker fungus *Nattrassia mangiferae* (H. & P. Sydow) Sutton & Dyko (Deuteromycotina, Sphaeropsidales) (formerly *Hendersonula toruloidea* Nattrass) has been consistently associated with declining Pacific madrone trees. This fungus has been described as a weak, wound-invading pathogen on its other hosts (Paxton and Wilson 1965, English et al. 1974, Sutton and Dyko 1989).

Canker fungi often become more aggressive when the host is under water stress. Increased pathogenicity may be related to lowered photosynthetic activity in the host. The reason is thought to be that fewer defense chemicals are produced when photosynthesis is lessened (Boyer 1995) and that low molecular weight carbon and nitrogen compounds are available to pathogens (Wargo and Harrington 1991). Defoliation, water stress, and shade all affect the rate of photosynthesis.

In an early study of *Nattrassia* causing branch wilt in walnut (*Juglans regia* L.), it was found that the fungus had best growth on pectin as a sole carbon source and that it did not grow on cellulose. Microscopic examination showed that the xylem was not degraded, but the phloem was destroyed when the fungus used intracellular pectin as a food source (Paxton and Wilson 1965). Rather than degrading the xylem, the fungus moved into cells through pits causing wilt or staining. The *Scytalidium* anamorph of *Nattrassia* was studied as a possible biocontrol for wood decay in Douglas-fir poles because it was antagonistic to the decay fungus *Poria carbonica*. In a carbon source experiment, *Nattrassia* grew best on xylan and there was no growth on cellulose or lignin. These authors also reported that the fungus did not degrade the xylem (Ricard and Bollen 1967).

The soil environment can be easily manipulated, and so it would be useful to know if fertilizing the trees would enable them to resist disease by increasing their vigor and their ability to callus over cankers, or if adding N would instead feed the fungus and cause it to be more aggressive. Madrones naturally grow in sandy soils which are low in nutrients, and we would expect that their requirements for N to be fairly low. It was shown that madrone had a high nitrogen use efficiency (NUE = %N/photosynthetic rate) when compared to other sclerophylls (Field et al. 1983). It is likely that this species would not respond to fertilization, except possibly in the case of young trees.

We did a study of soil conditions and madrone health on several sites in order to determine if a relationship exists between soil factors and madrone health (Table 1). We found a strong relationship between the number of *Nattrassia* cankers and the mineralization rate, or conversion of organic N to ammonium ($\mu g\ N*g\ dry\ soil^{-1}*3\ weeks^{-1}$ incubated at 30 C, abbreviated as NH_4). Nitrification can be inhibited by acidic soils that occur under conifer litter, and the sites with the highest NH_4 had the most conifers growing with the madrones. These were later successional forests of the type that would occur in the absence of fire. These sites had the lowest NO_3, so the form of available N was more important than the total amount of available N. Total N in the soil was related to the amount of organic matter (OM) in the soil ($r = 0.93$). Sites where NH_4 predominates are higher in available N, because NO_3 is leached out of the soil more quickly than NH_4. A predisposing factor in madrone decline could be excess N inputs from fire suppression (more OM accumulating in the soil) and urbanization (more available N from auto

emissions and fertilizer runoff). We can speculate that there is more N uptake, but since madrone is very efficient in its use of N, the excess is available to the fungus.

Table 1. Tree health and soils data collected from sites in western Washington: Port Townsend (PT), Vashon Island (V), University of Washington campus (UW), Magnolia and Discovery Parks (M/D), and Seward Park (SP). Net NH_4 and NO_3 expressed as μg N*g dry $soil^{-1}$*3 $weeks^{-1}$ incubated at 30 C. Canker rating: 1: 0-5 cankers, 2: 5-15, 3: >15.

Site	DBH, cm	% live foliage	Canker rating	Soil pH (H_2O)	% OM	%N, total	net NH_4	net NO_3	% sand
PT	10.92	0.87	1.07	6.46	0.067	0.13	2.49	10.56	93.5
V	11.26	0.58	1.37	5.08	0.026	0.06	2.09	15.37	94.2
UW	44.21	0.49	1.8	5.82	0.13	0.32	4.79	15.56	90.5
M/D	40.04	0.31	2.3	5.09	0.076	0.19	11.59	9.7	92.8
SP	42.27	0.31	2.4	5.69	0.1	0.20	13.57	2.18	71.6

NH_4 is rapidly assimilated and converted into other compounds. It is toxic to plants at high concentrations, and under conditions of excess NH_4 in the soil, the tree uses carbohydrates to detoxify it by assimilating it into amino acids. The most commonly found amino acids in the xylem sap of trees are arginine (ARG), proline (PRO), glutamic acid (GLU), and glutamine (GLN).

The canker fungus *Hypoxylon mammatum* grew better on N sources produced by plants under water stress (Griffin et al. 1986). There has been no previous work on the N metabolism of *Nattrassia*, and we would expect it to behave like *Hypoxylon*, since it is also a weak canker pathogen. Growth rates of *Hypoxylon* were higher on media with these amino acids as nitrogen source, with proline being the highest.

Objectives

To find the preferred C and N sources for growth of *N. mangiferae* and the optimum concentration for its growth in culture. We tested the hypothesis that *Nattrassia* has better growth on media containing metabolites produced by trees under stress.

Methods

The three isolates of *N. mangiferae* from Pacific madrone cankers used in this study were taken from Magnolia Bluffs, Seattle, WA, Vashon Island, WA, and Lake Sonoma Park, CA.

Carbon Nutrition: Three isolates of *N. mangiferae* were grown in liquid shake culture with 1% carbon source (5 replicates/isolate). The carbon sources were D-glucose, D-galactose, sucrose, pectin, xylan, and α-cellulose. The cultures were grown for one week at 25C and then filtered, dried, and weighed.

Nitrogen Nutrition: Three isolates of *N. mangiferae* were grown on media containing different forms and concentrations of N. Inorganic forms (NH_4, NO_3) were added to basal media in varying concentrations in order to determine optimum and toxic levels for fungal growth on each N form. Organic forms of N (amino acids) were tested singly (Griffin et al. 1986) at concentrations of 24 mM N. Amino acids were L-isomers of arginine, aspartate (ASP), glutamine, glutamate, leucine (LEU), lysine (LYS), and proline. Inorganic N (as NH_4NO_3) was also tested. Growth was measured by both radial growth rate and mycelial dry weight.

Data Analysis: Data were analyzed using 2-way ANOVA and the Tukey test, using SPSS version 10.0.

Results and Discussion

Carbon Nutrition:

The fungus was able to utilize all the carbon compounds tested except α-cellulose (xylan>D-glucose=sucrose=pectin>D-galactose> α-cellulose) (Table 2). This is in agreement with other studies. The best growth was on xylan, a hemicellulose. Hemicellulose makes up 20-25% of the dry weight of most hardwood species, and could be a significant source of carbon for fungal species with the appropriate enzymes. Values for pectin were lower by half than those obtained by Paxton and Wilson (1965) in the walnut branch wilt study.

Table 2. Results of carbon source experiment. Liquid shake cultures with 1% carbon source were grown for 1 week at 25C. Each value is the average of 5 replicates of 3 isolates.

Carbon Source	Dry weight, mg (sd)	Function
D-glucose	69 (22) c	Formed in leaves by photosynthesis, free sugar pool
D-galactose	24 (10) b	Rarely free, usually in glycosides or polysaccharides
Sucrose	68 (38) c	Translocated in *A. menziesii* phloem
Pectin	60 (18) c	Soluble, intracellular, in phloem
Xylan	325 (59) d	Structural carbohydrate (hemicellulose), in secondary cell walls
α-cellulose	0 a	Structural carbohydrate (glucose)

If the fungus is using xylan as a carbon source *in vivo*, one would expect to see decay symptoms. Branches often break at the location of cankers, so there could be some weakening of the wood occurring. *Nattrassia* was grown in liquid culture with cellulose, but no growth occurred. Paxton and Wilson (1965) did not find a fungal cellulase present in infected walnut wood. In many host species, *N. mangiferae* causes wilt symptoms without degrading the xylem. Wilt symptoms are from plugging of the vessels by tyloses or gums and occur on walnut (Paxton and Wilson 1965), stone-fruit trees (Nattrass 1933), Eucalyptus (Matheron et al. 1994), grape, mulberry, pear (Ahmed 1973), and cashew (Singh and Misra 1980). However, sapwood on infected *Hevea brasiliensis* plants became weak and brittle in addition to wilt symptoms. Gumming and wood rot occurred in citrus (Calavan and Wallace 1954). Douglas-fir wood did not have weight loss in the biocontrol study (Ricard and Bollen 1967), and this could be because it has a lower xylan content than hardwoods.

Growth on sucrose was similar to glucose, indicating that the fungus may parasitize the phloem and use carbohydrates being translocated there. The fact that growth on these simpler carbon compounds was less than on more complex ones suggests that the fungus is adapted to growing on stressed trees, since production of these compounds slows during stress when photosynthesis is inhibited. There was no significant difference between isolates.

Nitrogen Nutrition

The optimum N concentration for growth of *N. mangiferae* was around 3 mM N based on dry weight (Figure 1) and around 5 to 10 mM for linear growth (Figure 2). Anything above 5 mM N was excess, although higher levels of NH_4 seemed to inhibit growth. There was a slight preference for NH_4 in dry wt and for NO_3 in linear growth. These differences were not statistically significant. The fungus does not seem to discriminate between inorganic N sources. A second experiment was done using higher levels of N and adding NH_4NO_3. The maximum growth rate occurred at 5 mM N in all cases, with some inhibition at higher levels of NH_4 (Figure 3).

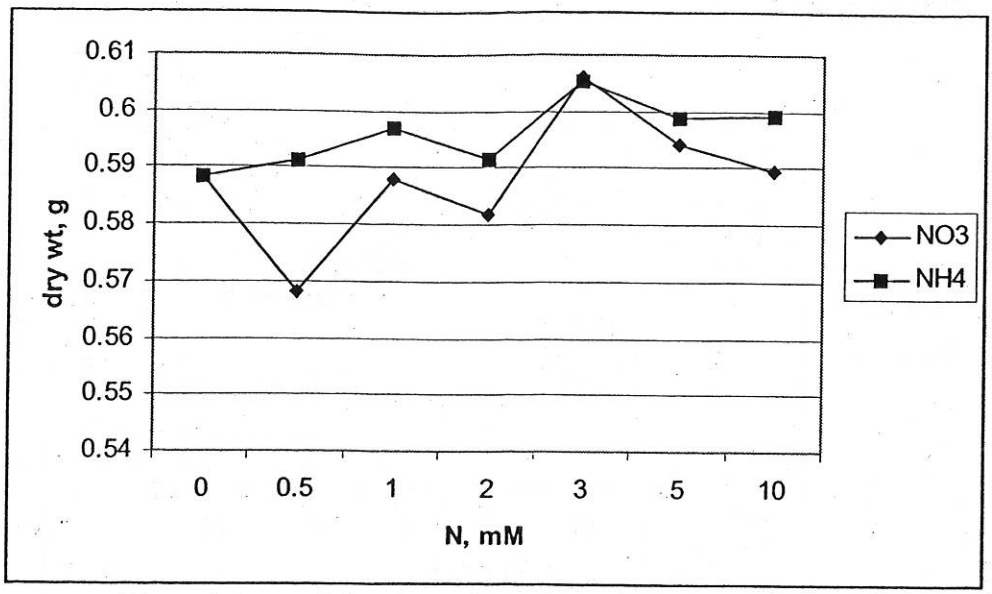

Figure 1. Dry weight of mycelium vs conc. inorganic N source.

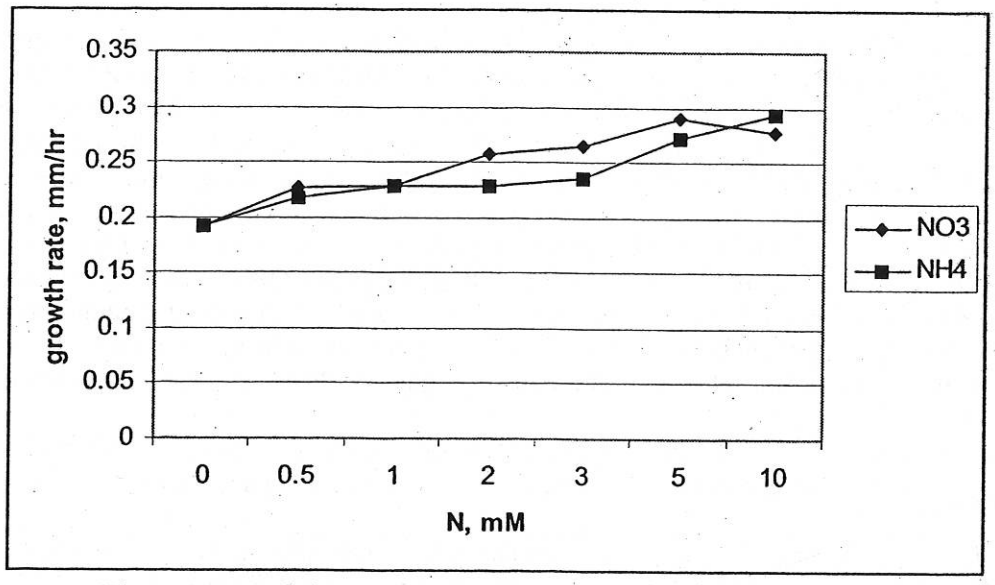

Figure 2. Mycelial growth rate at 25 C vs conc. inorganic N source

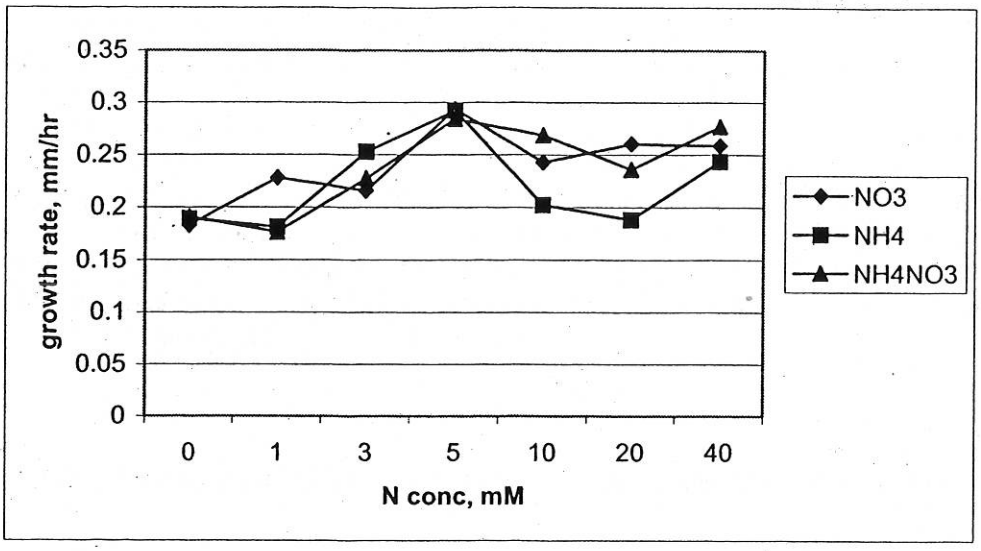

Figure 3. Mycelial growth rate vs conc. inorganic N source at higher concentrations and with NH_4NO_3 added, at 25 C.

In the amino acid experiments, linear growth rate and mycelial dry weight were correlated (r = 0.90). Growth on these N sources, in descending order was the following: PRO = GLN>ARG>NH_4NO_3>LEU>GABA>ASP>GLU>LYS>Blank (no added N) (Table 3). There was a small significant difference between isolates (p=0.04), with the isolate from Lake Sonoma, CA growing more slowly than the Washington State isolates on most N sources.

We expected good growth on PRO, ARG, GLU, GLN, and inorganic N, since these are found in xylem sap, and especially on PRO, GABA, and inorganic N, which are found in water-stressed plants in higher concentrations (Hanson and Hitz 1982). Growth on GABA was less than expected, but growth on PRO was the highest for all 3 isolates. There was poor growth on LYS, which is similar to GABA in structure, but it is not commonly found in xylem sap. This was also true in a study on *Hypoxylon* (Griffin et al. 1986). There was surprisingly good growth on LEU, but it varied greatly between isolates suggesting that it isn't essential for *Nattrassia* growth.

Table 3. Growth rates (mm/hr) of 3 isolates of *N. mangiferae* on different N sources (24 mM N). Values are mean of three replicates per isolate, homogeneous subsets in parentheses.

N source	Seattle, WA	Vashon Is., WA	Lk. Sonoma, CA	All isolates
Proline	0.34 (cde)	0.34 (cde)	0.34 (bcde)	0.34 (c)
Glutamine	0.35 (de)	0.36 (de)	0.31 (abcde)	0.34 (c)
Arginine	0.22 (abcde)	0.34 (abcde)	0.27 (abcde)	0.30 (bc)
NH_4NO_3	0.26 (abcde)	0.29 (abcde)	0.21 (abcde)	0.27 (abc)
Leucine	0.24 (abcde)	0.33 (bcde)	0.26 (abcde)	0.25 (bc)
γ-aminobenzoic acid (GABA)	0.25 (abcde)	0.23 (abcde)	0.20 (abcd)	0.23 (ab)
Aspartate	0.23 (abcde)	0.22 (abcde)	0.20 (abcd)	0.22 (ab)
Glutamate	0.23 (abcde)	0.19 (abc)	0.20 (abcde)	0.21 (ab)
Lysine	0.18 (ab)	0.16 (a)	0.21 (abcde)	0.19 (ab)
Blank (no added N)	0.17(a)	0.17 (a)	0.18 (a)	0.17 (a)

Summary

The canker fungus *N. mangiferae* grew best on xylan as sole C source. This may have implications in weakening of cankered limbs, either directly or by providing more substrates for decay fungi. There was less growth than expected on pectin. The fungus behaved as expected when grown on glucose, and sucrose. There was no growth on α-cellulose.

Nattrassia demonstrated no preference for NO_3 or NH_4 when grown on media containing these compounds as the sole N source. Best growth was on the amino acids proline (PRO) and glutamine (GLN), similar to the weak canker fungus *Hypoxylon.* Some further work will look at the amino acid composition of madrones under different conditions of N supply and water stress. *Nattrassia* grows well on metabolites produced by plants under stress, which is consistent with its being a weak canker pathogen. Under conditions of excess soil N, *Nattrassia* may cause disease by increased mycelial growth, rather than by toxin formation.

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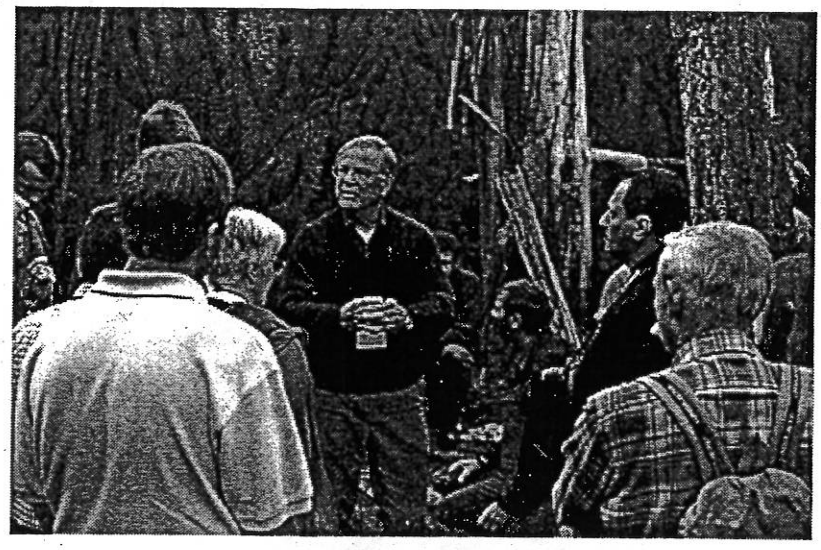

Dave Wood

Breeding for resistance to *Phytophthora lateralis* in Port-Orford-cedar : Current Status (2001) and Considerations for Developing Durable Resistance

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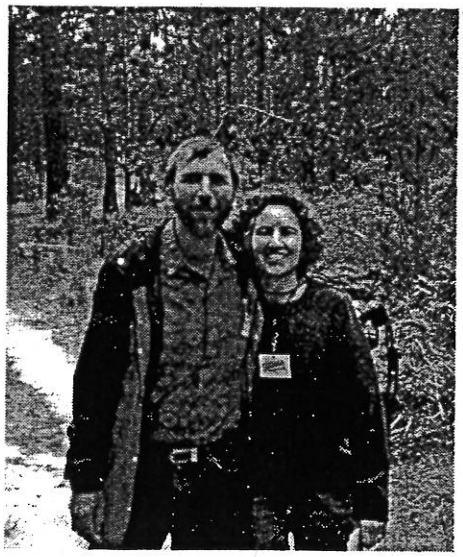
Port-Orford-cedar (*Chamaecyparis lawsoniana*) is an important component of the forest ecosystems of southwestern Oregon and northwestern California. The presence of a non-native root disease caused by *Phytophthora lateralis*, is causing widespread mortality throughout the range of Port-Orford-cedar. In 1997, the Forest Service and BLM in collaboration with Oregon State University initiated a operational breeding program for resistance. Including a few selections made prior to 1997, a branch dip test has been used to evaluate over 9700 field selections through 2000. Over 1000 candidates ranked high in the branch lesion test are being evaluated further using rooted cuttings in a root dip test or in field tests. Although the branch dip test appears only weakly correlated with other tests many of the highest surviving parents also are highly ranked in all tests. The frequency of resistant candidates is low, and depends on the criteria used to define a candidate as resistant. Large differences in family survival occur, sometimes varying from 0% to 100%. The oldest field tests indicate good survival through 12 years for rooted cuttings and seedlings of top parents. Some results from crossing suggest a major gene for resistance, but some minor conflict exists among the different types of tests. The number and types of resistance mechanisms are unknown, and may be difficult to discern without diagnostic races of the pathogen. Current evidence suggests there is relatively little genetic variability in this introduced pathogen. Breeding in Port-Orford-cedar can be done at a very early age which favors the development of increasing levels of resistance. Management activities that reduce the spread of the pathogen, the size of the pathogen population, or the introduction of new strains will aid in developing effective resistance.



Everett Hansen and Susan Frankel

SPECIAL PAPERS

Moderator: John Pronos, USDA Forest Service, Sonora, CA

Diseases and Insects in "Relatively Undisturbed" Mature Stands in Southwest Oregon

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INTRODUCTION

Southwest Oregon is very different from other forested areas in the Pacific Northwest and in fact is one of the ecologically most diverse regions in North America (Atzet and Martin 1991). Unique features that contribute to this diversity include an extremely varied geologic history, an associated abundance of very different soil types, a climate that is Mediterranean rather than temperate, a substantial role of fire in forest succession, and occurrence of important junctures between several north-south and east-west running mountain ranges that has led to significant migrations of plant and animal species into the region from elsewhere. Southwest Oregon forests contain 24 species of conifers and 14 hardwood tree species as well as an especially rich array of shrubs and herbaceous plants, a substantial number of which reach the northern, southern, or western extent of their ranges in Southwest Oregon or are endemic to the region.

Forest ecologists in Southwest Oregon classify plant communities based on potential natural vegetation (Atzet et al. 1996). The potential natural vegetation for a site is the vegetation that would be present under climax conditions, conditions that would develop without natural or human-caused disturbances. The climate of Southwest Oregon favors a frequent fire disturbance regime and this coupled with other disturbances, especially forest management activities by humans, results in the actual occurrences of climax vegetation being quite rare. Most forest stands have been burned several times or have had some harvesting, are multi-aged, and are in early or mid successional stages. The oldest trees are commonly less than 300-years-old. For such stands, potential natural vegetation is inferred using information on existing younger successional vegetation and knowledge of successional pathways.

The potential vegetation classification system has two levels of which the broader divisions are Plant Series and the finer divisions are Plant Associations. Series are described by the dominant, most shade-tolerant, regenerating species on the site. Plant Associations are described primarily by the presence, absence, and relative abundance of plant species. Environmental variables, including soil, are also used in the classifications and often reflect the pattern of vegetation. Species presence and abundance result from environmental gradients. Classification attempts to find plant responses to natural gradients such as slope, slope position, aspect, soil type, temperature, and moisture. To facilitate meaningful classification at the landscape scale, similar Plant Associations have been combined into Plant Association Groups.

Plant Series present in Southwest Oregon are the Sitka Spruce (*Picea sitchensis*), Oregon White Oak (*Quercus garryana*), Ponderosa Pine (*Pinus ponderosa*), Tanoak (*Lithocarpus densiflorus*), Douglas-fir (*Pseudotsuga menziesii),* Western Hemlock (*Tsuga heterophylla*), Western Redcedar

(*Thuja plicata*), Port-Orford cedar (*Chaemacyparis lawsoniana*), Jeffrey Pine (*Pinus jeffreyii*), White Fir (*Abies concolor*), Lodgepole Pine (*Pinus contorta*), Shasta Red Fir (*Abies magnificae* var. *shastensis*), Pacific Silver Fir (*Abies amabalis*), Western White Pine (*Pinus monticola*), and Mountain Hemlock (*Tsuga mertensiana*) Series. The Sitka Spruce and Western Redcedar Series have very limited distributions and were not included in the present evaluation. Each Series contains one to several Plant Association Groups. The 13 Series investigated in this evaluation contain among them 42 Plant Association Groups.

When forest ecologists were first developing the potential vegetation system for Southwest Oregon in the late 1970s and early 1980s, they established 1,200 plots in relatively undisturbed, mature stands that they felt best represented the various Plant Series and Plant Associations. These plots were not located randomly. Rather, location was dictated by occurrence of stands with the right histories and characteristics for the analysis. Nevertheless, the plots are quite well distributed across the three Southwest Oregon National Forests. Data from the Southwest Oregon ecology plots have been widely used in forest planning and management in the region. Not only has the classification system proven important for ensuring that vegetation management prescriptions are appropriate to individual sites and landscapes, but data on fire histories, numbers of snags, and amount of down wood from the ecology plots has been extensively used to develop management policies.

Unfortunately, no data on forest insects or diseases were originally collected in the Southwest Oregon ecology plots. The purpose of the present evaluation was to revisit a representative sample of the plots and collect this kind of information. Our objectives were to use plot data to get an idea of distribution of significant forest insects and pathogens in mature stands in Southwest Oregon, evaluate the magnitude of their impacts in such stands, and investigate the relationships between Plant Series and Plant Association Groups and the important forest insects and diseases. This evaluation, along with data from other surveys and large-scale forest inventories, will help us provide meaningful insect and disease information that is tied directly to the vegetation classification system used as the basis for silvicultural prescriptions.

METHODS

We randomly selected 327 of the 1,200 ecology plots for insect and disease evaluation. Plots chosen represented a 20 to 25 percent sample of all plots in each Plant Series and Plant Association Group. Plots were located in the field using the original ecologists' location maps and descriptions.

In each case after the plot center tree was located, we established a 20-basal area factor variable radius plot that was centered 10 feet to the north. All trees greater than 12.7 cm diameter at breast height in this plot were recorded by species, diameter, and condition (live, dead, standing, broken, down). All were carefully examined for signs and symptoms of commonly found insects and pathogens. At the same center point, we also established a 0.004 ha circular fixed area plot within which we recorded the same information for all trees less than 12.7 cm dbh but greater than 15 cm tall. We also established two 15.3 meter-long down wood transects starting at the plot center and running due north and due east. We recorded diameter and condition of all down trees and pieces of down wood 7.6 cm in diameter or greater that were intersected by each transect. Wherever possible, we recorded pathogens or insects that apparently contributed to the wood being on the ground. Finally, we gave a root disease severity rating to a 0.02 ha circular area surrounding plot center using the technique developed by Hagle (1985).

RESULTS

Some results of this work are reported below. Limited additional sampling will take place in 2002.

Fifty three percent of the 327 ecology plots sampled had trees affected by stem decays. Fifty three percent had trees affected bark beetles. Twenty-nine percent of all ecology plots sampled had trees affected by root pathogens. Twenty seven percent had trees affected by dwarf mistletoes. Thirteen percent of all ecology plots sampled had trees affected by white pine blister rust.

Stem Decays: *Phellinus pini, Phaeolus schweinitzii*, and/or *Echinodontium tinctorium* were present in 8 of 13 Southwest Oregon Plant Series. *P. pini* occurred in 60 percent of the Plant Association Groups with hosts. One to 19 percent of the trees were affected (mean of 5 percent). *P. schweinitzii* occurred in 50 percent of the Plant Association Groups with hosts. One to 13 percent of the trees were affected (mean of 35 percent). *E. tinctorium* occurred in 50 percent of the Plant Association Groups with hosts. Two to 23 percent of the trees were affected (mean of 6 percent).

Root Diseases: Root disease occurrence differed among Plant Association Groups and Plant Series. Root diseases were not detected on plots in the Oregon White Oak, Ponderosa Pine, Jeffrey Pine, Lodgepole Pine, or Western White Pine Series. Root diseases were present in the Tanoak (9 percent of plots examined), Douglas-fir (5 percent), Port-Orford-Cedar (42 percent), Mountain Hemlock (43 percent) White Fir (47 percent) Shasta Red Fir (40 percent) Western Hemlock (40 percent) and Pacific Silver Fir Series (67 percent). Relatively few plots with root diseases were found in any of the Plant Association Groups in the Douglas-fir and Tanoak Plant Series. Relatively large numbers of plots with root disease were found in many of the Plant Association Groups in the Port-Orford-cedar, White Fir, Shasta Red Fir, Pacific Silver Fir, Western Hemlock, and Mountain Hemlock Plant Series. On plots where root diseases occurred, root disease severity ratings ranged from 2 to 9. Overall average root disease severity ratings were lowest for plots in the Tanoak, Shasta Red Fir and Mountain Hemlock Series, intermediate in the Western Hemlock, Douglas-fir and White Fir series, and highest in the Pacific Silver Fir and Port-Orford-cedar Series. Root disease severity ratings were higher for plots with Armillaria root disease, laminated root rot, and Port-Orford-cedar root disease than for plots with Annosus root disease or black stain root disease.

Among Plant Association Groups that contained hosts susceptible to *A. ostoyae*, 52 percent had trees affected by the pathogen. Less than one to 33 percent of susceptible host trees in these Plant Association Groups were infected (mean of 5 percent). Percentage of trees infected by *A. ostoyae* was higher in the wetter Plant Association Groups than in the drier ones, and Plant Association Groups in the Pacific Silver Fir and White Fir Series had higher percentages of trees infected than other Series.

Among Plant Association Groups that contained hosts susceptible to *H. annosum*, 43 percent had trees affected by the pathogen. One to 16 percent of susceptible host trees in these Plant Association Groups were infected (mean of 4.6 percent). Percentage of trees affected by *H. annosum* was greater in Plant Association Groups that had stumps or numerous broken trees than in Plant Association Groups that lacked such infection foci. Some Plant Association Groups in the Pacific Silver Fir Series had the highest percentages of trees infected. Some Plant Association Groups in the White Fir and Mountain Hemlock Series also exhibited fairly high numbers of trees infected by *H. annosum* but less than with the Pacific Silver Fir Series.

Among Plant Association Groups that contained hosts susceptible to *P. weirii*, 14 percent had trees affected by the pathogen. One to 39 percent of susceptible host trees in these Plant Association Groups were infected (mean of 11 percent). Percentage of trees infected by *P. weirii* tended to be higher in the dry to mesic Plant Association Groups than in the wet ones, and Plant Association Groups in the White Fir Series and one in the Douglas-fir Series had the highest percentages of trees infected by *P. weirii*.

Among Plant Association Groups that contained hosts susceptible to *P. lateralis*, 31 percent had trees affected by the pathogen. Five to 78 percent of susceptible host trees in these Plant Association Groups were infected (mean of 50 percent). Percentage of trees infected by *P. lateralis* was high in Plant Association Groups where plots with hosts were located in wet areas, and, in addition to Plant Association Groups in the Port-Orford-cedar Series, one in the Tanoak Series had a high percentage of hosts infected.

Only one Plant Association Group that contained hosts susceptible to *L. wageneri* had trees affected by the pathogen. In that Plant Association Group, one in the Douglas-fir Series, 2 percent of host trees were infected.

Dwarf Mistletoes: Dwarf mistletoes were present in 11 of 13 Southwest Oregon Plant Series. Eleven percent of the Plant Association Groups with *Arceuthobium americanum* hosts had infected hosts, 38 percent of the Plant Association Groups with *A. campylopodum* hosts had infected hosts, 30 percent of the Plant Association Groups with *A. douglasii* hosts had infected hosts, 26 percent of the Plant Association Groups with *A. abietinum* f. sp. *concoloris* hosts had infected hosts, 10 percent of the Plant Association Groups with *A. abietinum* f. sp. *magnificae* hosts had infected hosts, 30 percent of the Plant Association Groups with *A. tsugense* subsp. *tsugense* hosts had infected hosts, and 35 percent of the Plant Association Groups with *A. tsugense* subsp *mertensianae* hosts had infected hosts. The mean percent of hosts affected within Plant Association Groups ranged from 8 to 34 percent for the different dwarf mistletoe species.

White pine blister rust: White pine blister rust was present in 11 of 13 Southwest Oregon Plant Series. Seventy-four percent of the Plant Association Groups with hosts had infected hosts. The percent of hosts affected within a Plant Association Group ranged from 2 to 100 (mean of 38 percent).

DISCUSSION

Results of this survey indicate that pathogens are important, are widely distributed, and have substantial impacts in mature forest stands in Southwest Oregon. Occurrence and impacts differ among Plant Series and Plant Association Groups. Based on this evaluation, Plant Association Groups in the Port-Orford-cedar, White Fir, Shasta Red Fir, Pacific Silver Fir, Western Hemlock, and Mountain Hemlock Series have the greatest overall amounts of disease in mature stands, probably because of more conducive site and environmental conditions as well as greater components of susceptible hosts in the stands.

The relatively high overall incidence and large amounts of root diseases found in our evaluation are especially interesting in view of the way that the ecology plots were originally selected. Plots were specifically chosen to be free of disturbance or at least "relatively undisturbed." Areas with evidence of harvesting or recent fires were avoided as much as possible and forested areas with essentially full canopy cover were preferentially selected. Areas with openings were discriminated against. Therefore, areas where root pathogens would be expected to have their greatest impacts were probably never selected for ecology plot locations. This suggests that, as

an overall estimate of root disease in mature Southwest Oregon stands, results from our survey are conservative, especially for those diseases that cause large amounts of mortality.

This evaluation provides us with some data for large-scale evaluations of mature stands and a foundation for risk/hazard rating of vegetation types that occur in Southwest Oregon. Investigations using these data and data from other plot systems that cover young stands, managed stands, and/or disturbed sites will further help to describe insect and disease conditions in Southwest Oregon forests.

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SPECIAL PAPERS

Moderator: Pete Angwin, USDA Forest Service, Redding, CA

A Survey of Whitebark Pine for White Pine Blister Rust in British Columbia

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Introduction

Whitebark pine (*Pinus albicaulis* Englm.) is a conifer species found at high elevations throughout the province south of 56° N latitude. Its growth form ranges from that of a wind-swept shrub (*krummholz*) to a large timber-producing tree. White bark pine trees are important for watershed protection, ecological succession, wildlife food and cover. The species is essential for the maintenance of subalpine ecosystem diversity. However, the future survival of whitebark pine is threatened by its susceptibility to white pine blister rust (WPBR), an exotic disease caused by the fungus *Cronartium ribicola* (J. C. Fisch.).

In British Columbia, WPBR attacks native five-needle pines, including limber, whitebark and western white pine. Since the introduction of the disease to Vancouver in 1910, it has spread throughout the province causing mortality of these species. The disease causes top die-back and direct mortality by killing the cambium, resulting in eventual girdling of the stem. Tree breeding to improve disease resistance is being done with western white pine in British Columbia but not with the other two species although they are considered more susceptible (Hoff *et al.* 1980).

Wildlife species that rely on whitebark pine seed for food (e.g., Clark's nutcracker, grizzly bear, and squirrels) and cover are vulnerable as the tree becomes locally threatened or removed from high-elevation locations. Whitebark pines do not begin producing seed until 20-30 years old with the interval between large crops being 3 to 5 years (Krugman and Jenkinson 1974).

Results from three years of surveys, conducted throughout the range of whitebark pine in British Columbia, are presented in this paper.

Objectives

The objectives for this study are:

1. To quantify the incidence of WPBR and mortality of whitebark pine; and
2. To relate various tree and site factors to the level of incidence and mortality; and
3. To identify other causes of tree mortality and defect; and
4. To identify potential parent trees for a breeding program.

Methods

Stands containing a significant component of whitebark pine were identified using the provincial forest inventory. Additional sites were identified in provincial parks. The field procedure roughly follows that used by Smith and Hoffman (1998). Once a stand was located, the surveyor visually inspected the first 50 live or dead whitebark pine trees encountered during a strip transect walkthrough. Only trees >1.3 m in height were included in the sample of 50. All trees were measured for diameter at breast height (1.3 m).

Detection of WPBR relied mainly on evidence of stem or branch cankers. Trees were assessed and placed into one of four categories: (0) live, uninfected trees; (1) live, WPBR-infected trees with one or more active stem or branch canker; (2) dead trees whose death can be directly attributed to WPBR; (3) dead trees where the cause of death is unknown or where the tree was clearly killed by an agent other than WPBR.

Other defects to the tree were noted in the comments. These include feeding by wildlife (e.g., squirrels, hares), mountain pine beetle, dead tops, excessive lean or sweep, forks and crooks, and scars. The presence of a cone crop was also noted. The elevation, latitude and longitude of each sample transect were also recorded.

A specific examination of whitebark pine regeneration abundance was also conducted during the last two years of the study. A 3.99 m radius (50 m^2) circular plot was placed 20 m into, and another 20 m before the terminus of, the strip transect. Within these plots all live and dead whitebark pine <1.3 m in height were tallied and grouped according to the same categories used for larger trees. Other regenerating tree species were also noted.

Mature, uninfected whitebark pines of good form were tracked for possible cone or pollen collection.

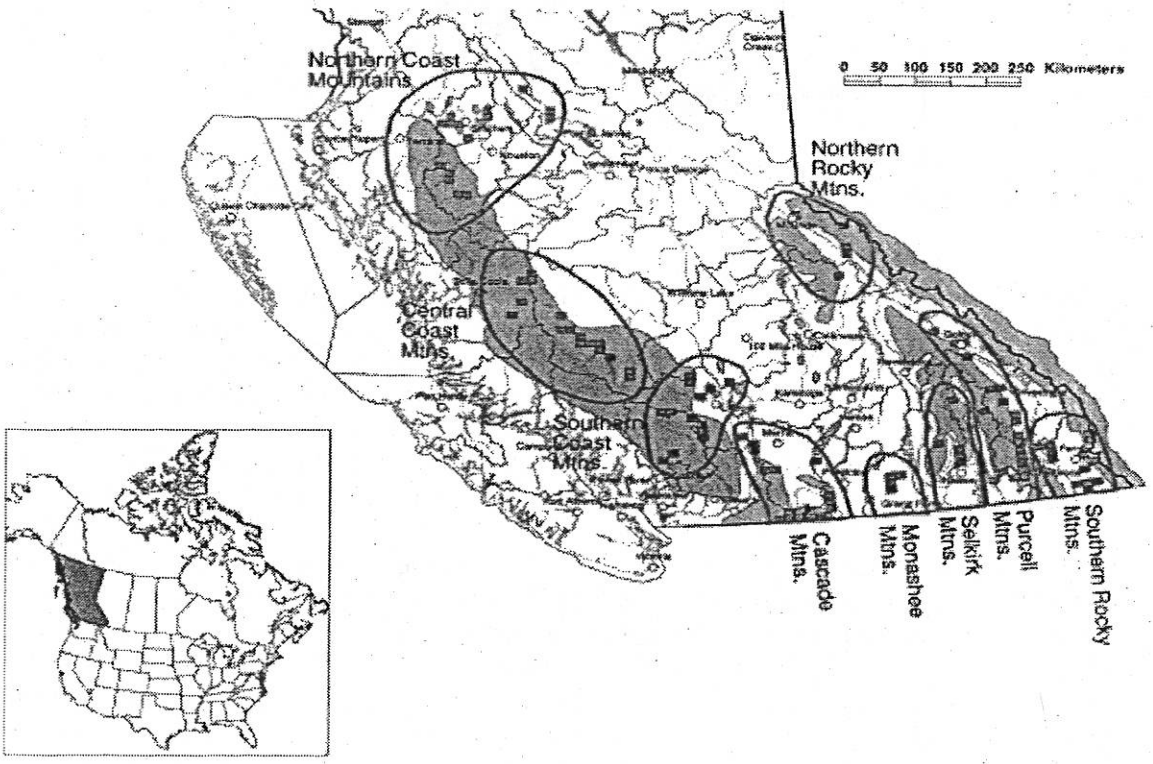

Figure 1. Distribution of sample plots across range of whitebark pine in British Columbia. Shaded area indicates range as described by Ogilvie (1990). Shaded boxes indicate area of samples. Shaded lines group together samples for analysis purposes.

Results and Discussion

Over the three years of the study, 483 transect lines were surveyed comprising 24,070 whitebark pine trees >1.3 m in height (Fig. 1). The single largest specimen at 132 cm dbh was found in the Van Horlick Creek area of the southern Coast Mountains. Data were also collected on 2533 seedlings (<1.3 m in height) found in the 829 regeneration plots.

Of the 24,070 trees examined, 4535 (18.8%) were dead (Fig. 2). Mortality on 2274 (50.1%) of these dead trees could be directly attributed to white pine blister rust. This figure is likely conservative as trees without obvious stem cankers were classified as dead due to other causes. These other causes include mountain pine beetle, abiotic factors, and unknown or unidentified causes. Of the remaining 19,535 living trees, 7430 (38%) were infected with blister rust. Of these infected trees, 4915 (66.2%) have stem cankers which will be lethal. The remaining infected trees display branch cankers that may grow to the main stem over time.

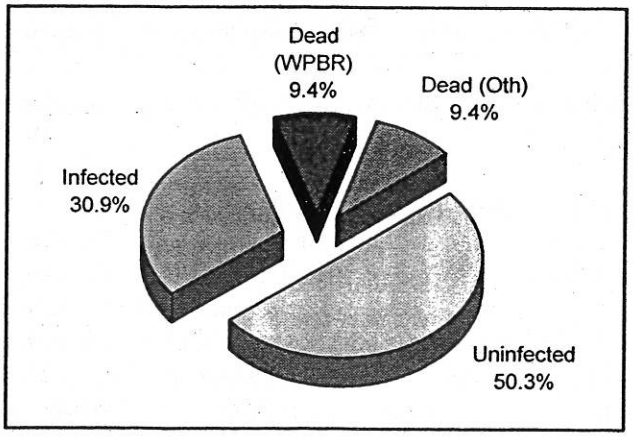

Figure 2. Summary of the condition of all whitebark pine trees >1.3 m in height sampled across the province.

In order to represent the impact of blister rust, the four categories of tree status were plotted against the diameter class distribution of the surveyed whitebark pine (Fig. 3). Results from pooled transects across the province show the smallest diameter trees are not the most affected but that combined infection and mortality surpasses 50% through the 5- 40 cm dbh range. The combined total falls for trees between 40-60 cm dbh before increasing again for trees >60 cm dbh. This indicates that a large portion of the reproductive cohort is being eliminated relatively early in their lives. This will have a negative effect on the natural distribution of whitebark pine.

This pattern does vary across the province. When survey transects are pooled by geographic area (usually by mountain range or portion thereof; see Fig. 1) definite differences in the distribution of infection occur. For example, the southern Coast Mountain area shows a combined level of infection and mortality that increases gradually to peak at about 55% for the 15-20 cm dbh class. The level then tapers off to zero by the 50 cm dbh class. No large stems are reported killed, or are even currently infected, by WPBR. In contrast, high infection areas like the southern Rocky Mountains show combined peaks of between 80-90% that hold from 5-50 cm dbh. Large trees are often infected and many are dead due to WPBR. Most other areas are somewhere in between but there does appear to be a trend for infection to increase from west to east across the province.

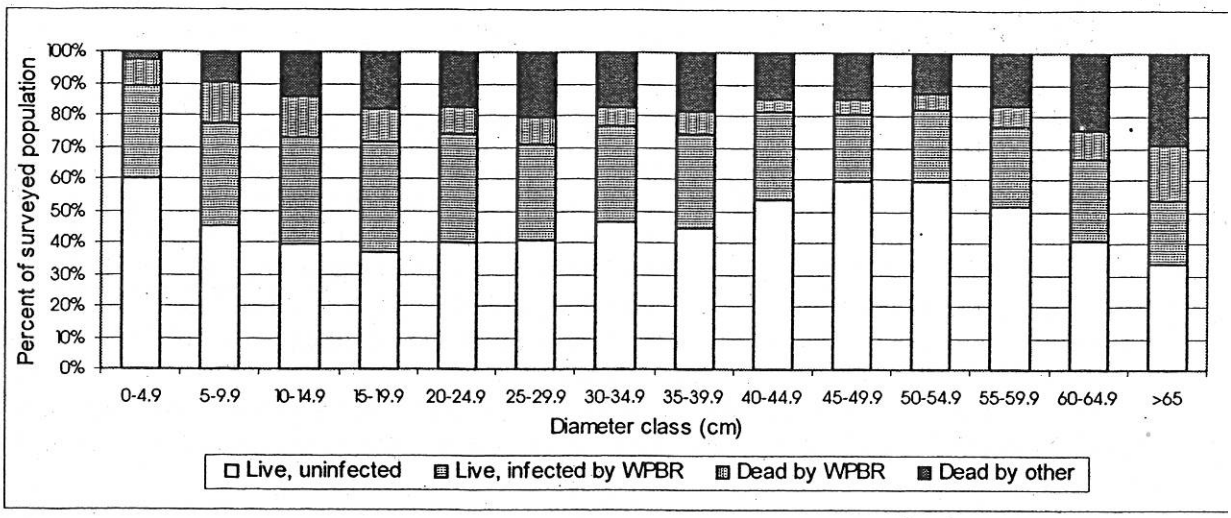

Figure 3. Four tree status categories plotted by diameter class for all whitebark pine >1.3 m in height across B.C. (n=24,070).

As might be expected for a species that inhabits high-elevation sites, many surveyed trees exhibit damage typical of harsh conditions. This damage alone is not usually fatal. It includes scars (21.9% of trees), dead or broken tops (13.4%), forks or crooks (8%), basal sweep (27.7%) and stem lean (11.7%). Trees often had more than one of these types of damage. Damage was also caused by other pests including mountain pine beetle (0.2%) and wildlife (11.5%). The level of beetle kill is quite low considering the province has been experiencing an epidemic outbreak in many areas over the past few years. The wildlife-caused damage is usually due to feeding by squirrels and, to a lesser extent, hares. Squirrel feeding in the spring has been well-documented on blister rust canker margins when other food sources may be scarce.

The results from the 829 regeneration plots measured over the final two years show that 37% of the plots had from 1 to 5 whitebark pine seedlings. In a further 14.4%, more than five seedlings were found. The remainder of the plots contained no whitebark pine regeneration. Combined, the regeneration plots contained 2533 whitebark trees, 85% of which were unaffected by white pine blister rust (Fig. 4). Of the remainder, 4% were currently infected by blister rust while 11% were dead, the cause roughly split between WPBR and other or unknown causes.

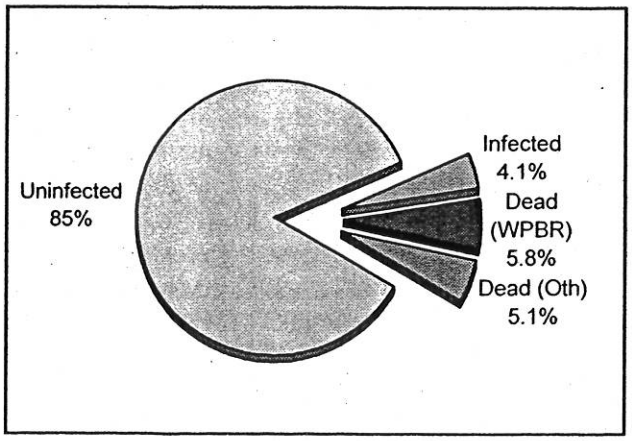

Figure 4. Summary of the condition of whitebark pine regeneration <1.3 m in height sampled across the province.

This survey was conducted during the late summer and early fall. Aeciospores were still being discharged from cankers on several trees (6%) in many areas. No study of the amount and condition of the secondary host (*Ribes* spp.) was conducted.

Recommendations

Four recommendations have arisen from the results of this study. The first is to halt the harvest of any surviving whitebark pine in order to preserve the gene pool and maximize natural reproduction. The second is to reintroduce fire into high-elevation ecosystems to ensure that suitable seed caching locations are readily available. Some experimental work on reintroducing fire is already being conducted in federal parks by Parks Canada (Rob Walker, personal communication). Next is to begin collecting wild seed for use in reforestation efforts. The BC Ministry of Forests has started small-scale efforts along this line that will lead to the development of test plantations (Dave Kolotelo, personal communication). Last, a long-term tree breeding effort, along the lines of the current program for western white pine, needs to be started to try and reinforce any natural resistance native populations might have to white pine blister rust.

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The Role of Ribes: White Pine Blister Rust in the Greater Yellowstone Area

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White pine blister rust is recognized as the most damaging North American conifer disease. Impacts from the disease are being documented in relatively pristine forests such as those of the Greater Yellowstone Area. This ecologically important region includes roughly 18 million acres comprised of Yellowstone and Grand Teton National Parks and the surrounding lands. Recent and on-going surveys show that blister rust occurs in a patchy and variable distribution in this area, with some sites highly infected and some sites apparently not infected. Whitebark pine (*Pinus albicaulis*) and limber pine (*Pinus flexilis*) are the only white pine species that occur within the Greater Yellowstone Area, with whitebark pine inhabiting more acreage than limber pine. Whitebark pine is a hardy high-elevation species that provides watershed protection, wildlife cover, and an important food source for birds, small mammals, and bears, including the federally protected grizzly bear. White pine blister rust may be the most severe threat that these valuable trees are facing, and conservationists and wildlife biologists have an interest in understanding the disease and its expected impacts. Research and management programs are becoming established to meet this objective, but have not included the role of the obligate intermediate hosts of the disease cycle, the *Ribes* species.

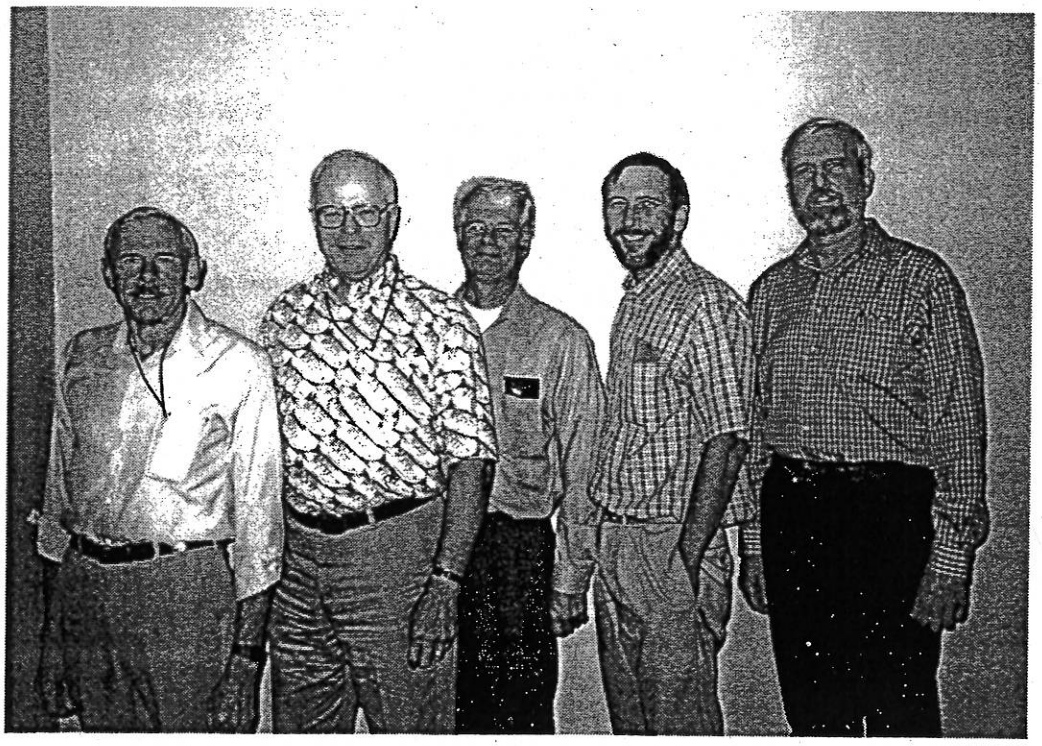
The overall objective of my master's thesis at the University of Montana is to provide information on how each *Ribes* species may contribute to disease spread and intensification within the Greater Yellowstone Area. Specifically, I am studying the following questions:

1) Are there site characteristics related to host plant densities and distributions that correlate with whitebark pine infection level?
2) Does the annual timing of ribes leaf development influence ribes infection levels?
3) What environmental conditions occur within the canopies of ribes plants in whitebark pine forests?

During the summer of 2001 I visited whitebark pine stands that exhibited a gradient of blister rust infection levels (from no apparent infection to severe infection). At each site I collected quantitative data on whitebark pine density and distribution, ribes densities by species, the presence and level of ribes spatial associations with whitebark pine, and overstory canopy cover. I studied the timing of ribes leaf development relative to ribes infection level by conducting a pilot experiment manipulating leaf phenology. During late spring snowmelt I piled snow on treatment ribes plants that had not yet leafed out. Additionally, I marked control plants that had also not leafed out and had no snow cover under natural conditions. Later in the summer I noted that both control and treatment plants appeared to be infected at similar levels, suggesting that either the manipulated phenology delay was not substantial enough, or that phenology may not be a significant factor in infection levels. Finally, I studied ribes canopy environmental conditions by deploying data loggers within host plants, recording rainfall, relative humidity, air temperature, and estimated leaf wetness. Data collected during the summer of 2001 is currently being analyzed.

Field time during summer 2001 was also useful for collecting qualitative data on ribes distributions and relative infection levels. There are four species of ribes that may be important

in the local blister rust disease system: *Ribes hudsonianum*, *R. lacustre*, *R. montigenum*, and *R. viscosissimum*. I observed widespread infection on *R. montigenum*, a species whose susceptibility has not been well established. This information, coupled with the data on environmental conditions, may elucidate what conditions are necessary for infection on this species. I hope that these data will increase our knowledge of the blister rust disease system and future impacts on whitebark pine, a critical species within the Greater Yellowstone Area.



Why are these men smiling? Because they were all students of Bob Patton at the University of Wisconsin! Left to right: Tom McGrath, Walt Thies, Dave Johnson, Everett Hansen and John Pronos

Impact of prescribed fires in Ponderosa Pine Stands in the Southern Blue Mountains on Various Components of the Ecosystem—three years post fire.

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ABSTRACT

Prescribed burning to reintroduce fire into ponderosa pine ecosystems is being done with inadequate knowledge of the influence of fire on many ecosystem components. A study in ponderosa pine forest type compared season of burn with the incidence of root diseases and insect attacks. Three treatments (fall 1997 burn, spring 1998 burn, and no burn) were applied to 30-acre plots and replicated in six stands in southeastern Oregon. Tree, stand, and site characteristics, and first order fire effects were measured. In general, duff consumption, basal charring, crown scorch and tree mortality were less with spring burns than with fall burns. Seven of eight species of root feeding beetles (potential vectors of black stain root disease), captured in flight traps, showed an attraction to burned sites. Most of these insect species preferred fall burned plots. Lichen species are dramatically better able to survive heat from fire than ponderosa pine needles or buds but are not good predictors of tree survival. The authors invite others to participate in developing additional collaborative studies using this established well-replicated study platform.

INTRODUCTION

Prescribed burning is currently being used as a restoration and management tool to reduce fuel loads and restore ecosystem function in western interior forests. Many ponderosa pine stands are currently past their historic fire return interval. Heavy fuels build-up and ample fuels ladders, put stands at risk for catastrophic wildfire. More than one burn may be necessary to reduce fuels adequately and minimize fire-caused tree mortality. The effects of different prescribed burning regimes on ecosystem structure and function are poorly understood. Managers are also concerned about how the seasonal timing of stand-treatments affects second order fire effects such as the spread and impact of insects and diseases. These local knowledge gaps are significant to fire management plan development and implementation in the Blue Mountains.

In 1995 we began to investigate the influence of stand treatments on black stain root disease (BSRD) and its potential insect vector(s). Beetle trapping demonstrated significantly greater numbers of potential vectors in burned or thinned ponderosa pine stands than in undisturbed areas. That beetle flight generally occurs during and immediately after spring burning, added to the urgency for information with which to plan the timing of prescribed burns. In response, in 1997, we began a 3-year study to examine the effect of season of prescribed burning on BSRD and possible root feeding beetle vectors. Observations were expanded to include: bole-infesting beetles, decomposition, lichens, primary fire effects, soil and litter arthropods, soil nutrients, understory vegetation, and woodpeckers.

The purpose of this communication is to present an overview and preliminary results from our study of the impact of the season-of-burn to a variety of ecosystem elements in ponderosa pine stands.

STUDY DESIGN

STUDY SITES: The study was established in six stands of mixed-age ponderosa pine with scattered western junipers in the south end of the Blue Mountains (Emigrant Creek Ranger District,

Malheur National Forest) near Burns, Oregon. Stand elevation ranges from 5160 - 5850 ft. At the start of the study trees in the stands were generally 80 - 100 years old with intermittent individuals of about 200 years; average diameter breast height (DBH) was 10 - 13 inches, mean tree height ranged from 40 - 54 feet, and all had scattered trees with BSRD. Plots contained 78 - 137 trees per acre, and basal area ranged from 72 - 91 square feet/acre. Each stand was thinned in 1994 or 1995 and was designated for underburning. The stands are in three locations designated as Trout, Kidd Flat, and Driveway, with 1, 1, and 4 stands respectively. General descriptions of the stands follow:

Trout

- Aspect: W; Elevation: 5400 ft.; Precipitation: 15"/year; Lat/Long: 43° 48'N 118° 56'W
- Plant community: PIPO/CAGE, ponderosa pine/elk sedge
- Soil: Gravelly loam and clay loam, bedrock is hard basalt and andesite
- Stand age: 80 - 100 years with frequent individuals that are about 200 years

Kidd Flat

- Aspect: NE; Elevation: 5400 ft.; Precipitation: 20"/year; Lat/Long: 43° 47'N 118° 57'W
- Plant community: PIPO/SYOR ponderosa pine/mountain snowberry
- Soil: Loam to gravelly loam, bedrock is moderately hard rhyolite
- Stand age: 80 - 100 years with intermittent individuals that are about 200 years

Driveway

- Aspect: SW; Elevation: 5600 ft.; Precipitation: 15"/year; Lat/Long: 43° 53'N 118° 45'W
- Plant community: PIPO/FEID, ponderosa pine/Idaho fescue
- Soil: Gravelly loam and clay loam, bedrock is hard basalt and andesite
- stand age: 80 - 100 years with intermittent individuals of about 200 years

EXPERIMENTAL UNITS AND TREATMENT: Each stand was designated as a replicate and divided into three contiguous experimental units similar in type, aspect, and slope and approximately 30 - 60 acres each. Unit boundaries were established along topographic features with consideration for control of the underburning. Three treatments (no burn, fall burn, and spring burn) were assigned randomly to the three experimental units in each stand. Underburning was planned to maintain a 2-foot flame length and to reduce fuel loading and stocking of regeneration. Experimental units were burned during mid-October of 1997 or mid-June of 1998. All burns were carried out within the burn prescription and were representative of operational burns given weather and fuel conditions. Because of the timing of the burns, at each examination all 18 experimental units will have developed without further disturbance for the same number of growing seasons.

DATA COLLECTION PLOTS: Within each experimental unit, six 0.5-acre circular plots were established post-fire to evaluate responses to the burns. Plots were located at least 300 ft apart on areas that represented the average stand and burn conditions on the experimental unit. Areas with few ponderosa pines such as a rock outcropping or a thicket of mountain-mahogany were avoided. Each plot center was located between two trees conveniently located for hanging an insect trap. Plot centers were marked with a metal pin and mapped to facilitate relocation.

Tree data and first order fire effects data were collected on each plot. Standing conifers dead or alive (with the exception of junipers) greater than 3.0 inches DBH were tagged. In fall 1998, the end of the first growing season after the prescribed burns, the following data were collected from tagged trees (n = 5436): species, condition (live/dead), needle complement, top kill (insect), top damage (other than fire), total height, height to live crown before fire, DBH, and diameter stump high. The following were collected on each quadrant of the tree: maximum height of charring, degree of charring at the base, consumption of litter. Bark thickness was measured for every fifth tree on the unburned plots and on the burned plots any trees with bark that appeared fully scorched or consumed. Each plot was revisited in the falls of 1999 through 2000 to record tree mortality.

Beetle activity was evaluated by flight trapping and recording bole attacks: Flight Trapping: Each experimental unit was monitored for lower bole and root feeding beetles using Lindgren traps baited with alpha-pinene and ethanol. Preburn: In spring 1997, traps were placed on each of the 18 treatment blocks to establish species and background populations of potential BSRD vectors. Postburn: In spring 1998, plots were established and a Lindgren trap was suspended at each plot center. Insect captures were collected every two weeks from June through August in 1998 and 1999. Bole Attacks: Attacks by *Dendroctonus valens* and other *Dendroctonus* spp. (we avoided chopping into live trees and so did not differentiate between mountain pine beetle and western pine beetle) were counted in October 1998, October 1999, and September 2000. Attacks were recorded as new, old, or pitched out in each tree quadrant. Wood borer attacks and woodpecker activity were also recorded.

Observations were made to examine the seasonal effects of prescribed burning on epiphytic lichens and their possible use as indicators of tree survival. Eight systematically selected trees trees were examined on each plot. Data included abundance, distribution and species of surviving lichens observed on each tree post burning.

DATA ANALYSIS: The initial statistical design is a randomized complete block with each of the six stands as a replicate. This will be used to evaluate questions of treatment (fall, spring, and no burn) differences. Logistic regression split on season of burn will be used to determine which stand, tree, and fire parameters best predict which trees will be killed outright by the fire (first order fire effects) and which by beetles or disease (second order fire effects).

INTERIM RESULTS AND DISCUSSION – THREE YEARS POST FIRE

The following is a narrative summary of the study to date. Data summaries, graphs, statistical analyses and more specific conclusions, such as were presented at this meeting (WIFDWC 2001) will be forthcoming in scientific papers.

The following are the tree data means by treatment and the number of live and dead trees, three years post burn:

TREES THAT SURVIVE THE UNDERBURNING						TOTALS AS OF FALL 2000	
STAND	NO. OF TREES	DBH (in.)	HT (ft.)	BA (sq ft/ac)	TREES PER ACRE	NO. TREES ALIVE	NO. TREES DEAD
NO BURN	1619	11.2	45.8	78.2	93	1597	22
FALL	1726	10.8	47.0	76.9	96	1310	416
SPRING	1742	10.9	45.8	80.9	97	1592	150
TOTAL	5087	11.0	46.2	78.7	95	4499	588

DISEASE: The evidence for a disease-fire interaction is inconclusive to date. While there was substantial tree mortality during the two years following burning, most died from fire related damage, a relatively small percentage (about 3 percent of the total) of the trees examined showed symptoms of BSRD, or annosus root disease. The total number of dead trees with either BSRD or annosus root disease found in the burned areas was greater than the total number found in the unburned areas, but numbers were too low for meaningful analysis. Since it can take several years for development of the disease, we expect fire related BSRD-caused tree mortality to begin to occur three to five years after burning. In the first few years, post-burn mortality of diseased trees is likely to result from a combination of preburn damage to the trees by the pathogens and stress (damage) from the underburning.

INSECTS: Nine species of root and lower bole infesting beetles were captured in flight traps with high enough frequency to recognize them as generally abundant and allow for meaningful statistical evaluation of the data. The root feeding and lower bole beetles responded to the treatments immediately, with higher abundance of all but two species in the burned units in 1998. These beetles differed in their response to fire, with four species more abundant in areas receiving fall burn treatments, two species with higher captures in areas receiving spring burn treatments and one species equally abundant following either season of burn. By the second year after burning, flight capture of most of the root feeding and lower bole infesting beetles was similar in unburned and burned treatments.

The response of all the bole infesting beetles was consistent. More trees were attacked in burned areas than in unburned areas, and more in fall than in spring treatment areas. These relationships were more pronounced the second year after burning. Attacks by primary bark beetles (other *Dendroctonus*) were infrequent, 10 percent or lower, all three years. The first two years postfire, 20 - 30 percent of the trees in burned units had new *D. valens* attacks, with numbers dropping substantially in 2000. This species is often associated with fire-scorched trees, and though it does not normally become epidemic, it may weaken trees and make them susceptible to fatal attack by more aggressive bark beetles. Wood borer infestation ranged from 15 - 60 percent of the trees attacked in burned sites, with numbers increasing somewhat from 1998 to 1999 and remaining about the same in 2000. Wood borer larvae first mine in the cambium region and then extend their tunnels into the wood. While few species of wood borers are considered major pests, a program of systematic prescribed burns could stimulate populations to the point where they would kill trees outright or weaken trees for attack by other insects.

A study to assess the effect of season of burning on litter macroarthropods, particularly ground beetles (Carabidae) and spiders, was conducted on four replicates of this study using pitfall traps. Data was analyzed for total abundance and species diversity. Fire had relatively little affect on overall carabid abundance. The fall burns occurred in mid-October, when many carabids are quiescent; they are often underground and therefore protected from the impacts of fire. If active, they are mostly adults that have the ability to flee and escape the fire. Spring burns were conducted in the third week of June, a time when many carabids are breeding, and others may be in the larval stage. Based on their biology and phenology, this is a time when carabids are likely to be susceptible to direct mortality from fire. However, spring burns tend to be of relatively low intensity and are heterogeneous, leaving many unburned patches that could act as refugia for mobile arthropods. After burning, Simpson's diversity index for carabids was significantly higher in the fall burning treatment than in spring burned and unburned areas. There was no difference between unburned and spring burned treatments. Fire reduced the overall abundance of spiders, with fall burns having a more negative impact than those occurring in the spring. Considerable direct mortality might be expected from spring burning since fires are conducted during a period of breeding and reproductive activity for many species. However, in general spring burns are of lower intensity and coverage is not as complete as fall burns, leaving unburned patches where mobile spiders can escape. The higher intensity of fall burns can affect spiders through direct mortality of individuals and by alteration of the litter habitat. Litter depth and structure can affect the abundance and community composition of spiders through their influence on prey availability, microclimatic conditions, and refugia. After burning there were no differences in Simpson's diversity index for spiders among any of the treatments.

FIRST ORDER FIRE EFFECTS: In general, duff consumption, basal charring, crown scorch and tree mortality were less with spring burns than with fall burns. As expected, crown scorch and

percent mortality were highest for the smaller-diameter trees. Charring at the base of trees and the consumption of litter/duff around trees was greater for larger diameter trees and were higher in fall burns. Percent mortality and percent crown scorch are highest in fall burns. Spring burning reduces overall mortality, however, it may not sufficiently reduce stocking levels. Trees with a DBH from 3 to 7 inches exhibited 11 percent mortality with a spring burn and 38 percent mortality with a fall burn. Preliminary results of analysis by logistic regression indicate that (for this data set) only crown scorch percent is a useful predictor of probability of tree mortality. Further, there is a highly significant difference between the curves for fall burn and spring burn. For example, with 90 percent crown scorch, trees in the fall burn treatment had a mortality probability of 0.7, while trees in the spring burn treatment had a mortality probability of 0.3.

LICHENS: While lichen survival was observed at a lower height with the lower fire intensity spring burn (5.2 ft.) than with the higher fire intensity fall burn (7.9 ft.; n = 288 trees/treatment), there was little difference in the height of lichen survival between the spring burned (5.2 ft.) and unburned (4.4 ft.) areas. The lichen species appear better able to survive the heat from the fire than do ponderosa pine needles. The mean height of survival of pine needles (24.0 ft) was dramatically greater than the mean survival heights of the lichens (6.5 ft. n = 591 trees). The most frequently observed lichen species included *Bryoria fremontii, B. fuscescens, Nodobryoria abbreviata, Letharia columbiana,* and *L. vulpina.* Selective thinning and burning creates favorable open conditions for the growth of these epiphytic lichen species.

THINGS TO COME: Observations have been made on additional components of the ecosystem on this same study site. Data is being analyzed and reports will be prepared on microarthropods, soil characteristics, understory vegetation, and woodpeckers. In addition to continuing to monitor the plots for disease development and tree mortality, two additional studies have been proposed for this study area and funding is being sought: 1. Examination of the impact of two intervals of prescribed fires (5 years and 15 years) on various components of the ecosystem. 2. Development and composition of understory vegetation following prescribed fires with and without grazing.

INTERIM TAKE HOME MESSAGES

1. Root and lower bole infesting beetles were most abundant and showed the greatest treatment differences the first season following fire.
2. Most root and lower bole infesting beetles were more attracted to burned areas than unburned areas; with preference for spring and fall burns varying by species.
3. *D. valens* and wood borer attacks were more abundant in burned than in unburned areas.
4. Burning affected the diversity but not the abundance of carabids.
5. Burning affected the abundance but not the diversity of spiders.
6. With similar crown scorch a smaller percentage of trees die following a spring burn than a fall burn.
7. Lichens are dramatically better able to survive underburning than are ponderosa pine needles but lichens are not good predictors of tree survival.
8. The authors invite others to participate in developing additional collaborative studies using this established well-replicated study platform.

POSTERS

Brown Root Rot Disease in American Samoa's Tropical Rainforests

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Introduction

Brown root rot disease (*Phellinus noxius* (Corner) Cunningham) causes tree decline and mortality throughout the tropical Pacific. It affects many woody hosts, including rubber, cacao, mahogany, and fruit and landscape trees. It is mainly known in American Samoa as a disease of breadfruit but has also been observed in primary rainforests. A rapidly increasing population is forcing farmers to clear native forest and land infested with *P. noxius* may affect agroforestry. The purpose of this study was to determine the incidence, distribution and host range of *P. noxius* in primary and secondary forests on Tutuila Island, American Samoa.

Methods

We measured the incidence and distribution of *P. noxius* in four established Department of Marine and Wildlife Resources (DMWR) plots and 16 strip transects. Areas of primary forest were selected for transects by vegetation type: montane, ridge top, slope, valley, coastal and plain. Secondary (disturbed) areas were also surveyed. Data collected included species of tree infected, diameter at breast height, location within a plot, and infection centers. Soil types were based on USDA Soil Conservation Service maps.

Cardinal symptoms of *P. noxius* infection include: brown to black mycelial crust on roots, lower stem, or both; moist, white margin on expanding crusts; and white, spongy, dry wood honeycombed with reddish-brown or black lines. Sporocarps with a gray-brown pore surface were occasionally present.

Results

- Infected forest trees included 37 species in 30 genera and 22 families (Table 1).
- Species most affected were *Myristica fatua* (25%), *Dysoxylum samoense* (16%) and *Hibiscus tiliaceus* (10%).
- Of 62 infection centers, 33 contained the same tree species.
- Five mycelial crusts measured >3 m, the highest 4.85 m on *D. samoense*.
- Reddish-brown lines in decayed wood were unagglutinated generative hyphae; black lines in older wood were composed of carbonaceous, agglutinated mycelium.
- Diameter at breast height of most infected trees was <30 cm but in DMWR plots the rate of infection was highest in trees >30 cm (Table 2).

Conclusions

- Brown root rot disease is widespread on Tutuila Island, American Samoa, occurring in all vegetation types surveyed.
- Primary montane and ridge tops had the lowest incidence of disease, secondary (disturbed) valleys the highest.

- Secondary valley sites lacked the species richness of mature stands and had the most, and largest, infection centers (Figure 1).
- Results suggest the epidemiology of *P. noxius* in tropical forests is similar to other host/pathogen associations (Douglas-fir/*P. weirii*, rubber trees/*P. noxius*) in which less disease occurs in mixed stands than in single species plantings.

Table 1. Forest species infected by *Phellinus noxius* on Tutuila Island, American Samoa.

Anacardiaceae
Rhus taitensis Guillemin
Spondias dulcis L.
Annonaceae
Cananga odorata (Lam.) Hook & Thoms.
Apocynaceae
Cerbera manghas L.
Barringtoniaceae
Barringtonia asiatica (L.) Kurz
Barringtonia samoensis A. Gray
Boraginaceae
Cordia aspera Forst. f.
Burseraceae
Canarium harveyi Seem.
Clusiaceae
Calophyllum neo-ebudicum Guillaumin
Combretaceae
Terminalia richii A. Gray
Ebenaceae
Diospyros samoensis A. Gray
Euphorbiaceae
Flueggea flexuosa Marg.
Glochidion ramiflorum Forst.
Macaranga harveyana (Muell.Arg.) M.Arg.
Macaranga stipulosa Muell. Arg.
Fabaceae
Adenanthera pavonina L.
Inocarpus fagifer (Parkinson) Fosb.
Intsia bijuga (Colebr.) Kuntze
Samanea saman (Jacq.) Merr.
Hernandiaceae
Hernandia nymphaeifolia (Presl) Kub.
Malvaceae
Hibiscus tiliaceus L.
Meliaceae
Dysoxylum samoense A. Gray
Moraceae
Ficus obliqua Forst. f.
Ficus tinctoria Forst. f.
Ficus sp.
Myristicaceae
Myristica fatua Houtt.

Table 1(continued). Forest species infected by *P. noxius* on Tutuila Island, American Samoa.

Myrtaceae
Syzygium inophylloides (A. Gray) C. Muell.
Syzygium sp.
Rhizophoraceae
Crossostylis biflora Forst.
Rubiaceae
Morinda citrifolia L.
Neonauclea forsteri (Seem. ex Havil.) Merr.
Sapotaceae
Planchonella grayana St. John
Planchonella samoensis H.J. Lam Christoph.
Sapindaceae
Elattostachys falcata (A. Gray) Radlk.
Pometia pinnata Forst.
Urticaceae
Pipturus argenteus (Forst. f.) Wedd.
Unidentified (25)

Table 2. Diameter of healthy trees vs. infected trees in DMWR 1.2 ha plots.

Diameter Class	10-30 cm	30-50 cm	>50 cm
Total No. Trees	81%	13%	6%
No. Infected Trees	55%	21%	23%

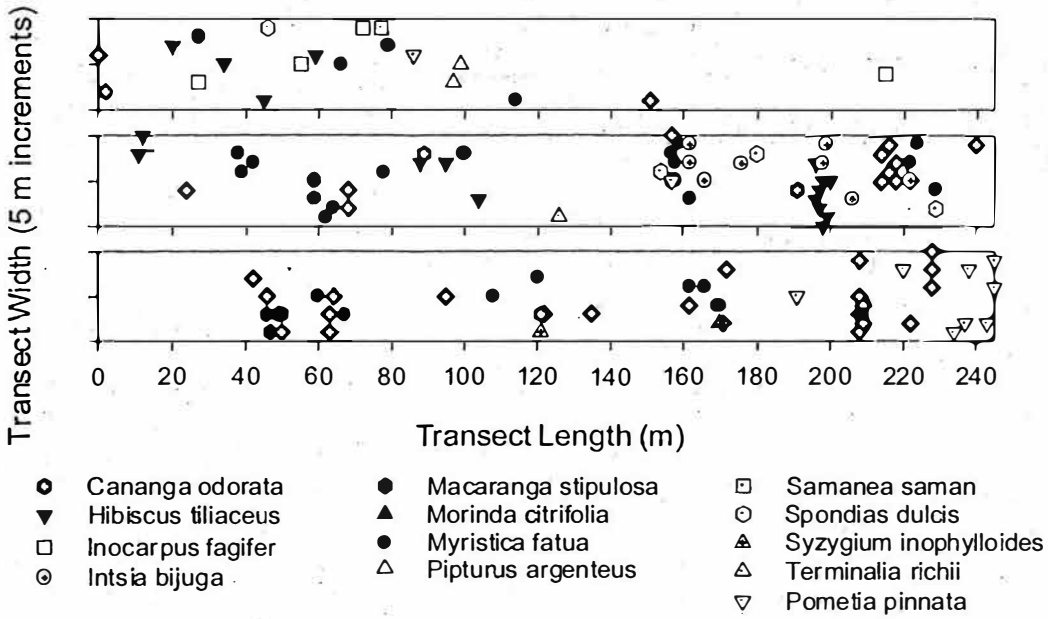

Figure 1. Three 0.25 ha strip transects in secondary (disturbed) valleys on Tutuila Island showing the distribution and species infected by *Phellinus noxius*.

Fred Brooks, Jim Worrall, Brian Geils, Diane Hildebrand and Eun Sung Oh

SUDDEN OAK DEATH IN OREGON

Ellen Goheen[1], Everett M Hansen[2], Alan Kanaskie[3], Michael G McWilliams[3], Nancy Osterbauer[4], and Wendy Sutton[2]

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[4]Oregon Department of Agriculture, Plant Division, Salem, OR

COOP Aerial Survey and Ground Check

Sudden Oak Death (SOD), caused by the pathogen *Phytophthora ramorum,* was first discovered in the United States in California. There the disease is responsible for the death of thousands of trees, including tan oaks (*Lithocarpus densiflorus*) and coastal live oaks (*Quercus agrifolia*). Southwest Oregon is home to many of *P. ramorum's* host plants. In an effort to evaluate if SOD was present in Oregon, the Oregon Department of Forestry and USDA Forest Service did an aerial survey. Eighteen potential sites were spotted from the air. These sites were further pinpointed with a helicopter survey. The following week a ground check was done by a team of forest pathologists from the Oregon Department of Forestry, the Oregon Department of Agricultural, the Forest Service and Oregon State University. Four additional clumps of dead tanoak were located at that time. Plant and soil samples were taken.

Survey Findings

Confirmed SOD sites in Oregon are all within an area of about 10 square miles, close to Brookings on the South Coast (Fig.1). The Oregon infestation is about 350 km north of the nearest confirmed site in the California epidemic area. SOD sites in Oregon have been confirmed by symptoms, isolation and morphology, and PCR. A non-specific *Phytophthora* ELISA test was also used. At two additional sites there is apparently another *Phytophthora* species present (Table 1).

Oregon Confirmed Hosts and their Symptoms

To date only 3 hosts have been confirmed in Oregon forests. The most common host is *Lithocarpus densiflorus* where SOD causes bleeding cankers and eventually death.
Rhododendron macrophyllum and *Vaccinium ovatum*, common understory plants in the tanoak forest, both display tip dieback and stem lesions.

Quarantine

When the presence of *P. ramorum* is confirmed at a site, the center and buffer zone are flagged off. The Oregon Department of Agriculture has enacted a quarantine for these centers that encompasses its square mile section. The quarantine forbids the transportation of tanoak, black oak, coast live oak, evergreen huckleberry, Oregon myrtle, rhododendron, and madrone. This includes all plant material and associated soils.

Eradication of the Sudden Oak Death pathogen, *Phytophthora ramorum*, in infected sites in Southwestern Oregon

- All host plants for *P. ramorum* with in the infection center will be cut down and bucked as needed.
- Host plants within a 50-100 foot buffer zone around the active infection centers will also be cut down.
- All host material from within the infection center and buffer zone will be piled and burned.
- There will also be a broadcast burn throughout the center and buffer zone to incinerate fallen leaves and duff.

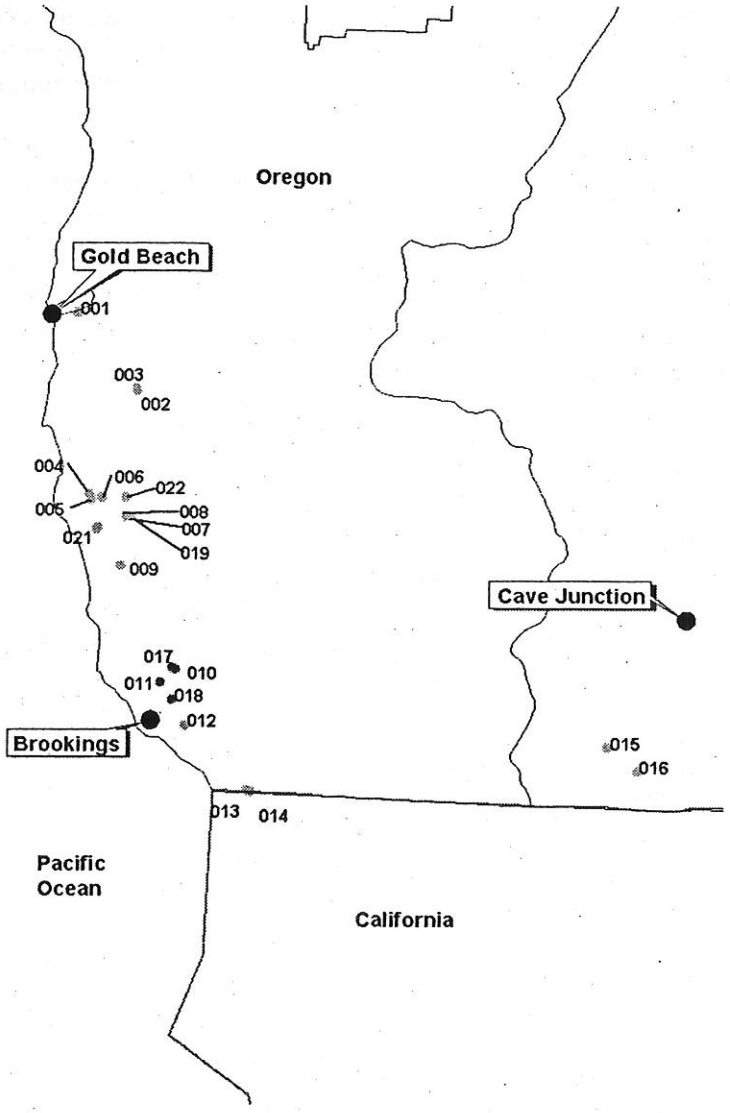

Figure 1. Suspected sites are numbered, with the presence of P. ramorum confirmed at sites 010, 011, 017 and 018.

Table 1. Survey findings.

Sites ID'd by Survey	Survey Findings	*P. ramorum* results Culture	Tissue PCR	*Phytophthora* ELISA
001	Oceanspray			
002	Armillaria and SOD symptoms	-	-	
003	Landslide with down tanoak			
004	Armillaria	-		
005	Armillaria and SOD symptoms	-	-	
006	Armillaria and SOD symptoms	-	-	
007	Tanoak with callused growth	-	-	
008	Armillaria and SOD symptoms	-	-	+
009	Powerline – brush cutting			
010	SOD symptoms	+	+	
011	SOD symptoms	+	+	+
012	Declining alder			
013	SOD symptoms	-	-	
014	SOD symptoms	-	-	+
015	Herbicide treatment			
016	Herbicide treatment			
017	SOD symptoms	+		
018	SOD symptoms	+	+	+
019	Armillaria and SOD symptoms	-	-	
020	SOD symptoms	-	-	
021	Armillaria and SOD symptoms	-	-	
022	Single dead tanoak	-	-	

Table 2. Isolation success for *Phytophthora ramorum* at SOD sites in August 2001.

Sample Type	Success/Plant or Soil Sampled	Success
Lithocarpus		
bark	11/22	50%
leaves and shoots	2/7	29%
Rhododendron	5/8	62%
Vaccinium	3/6	50%
Soil	4/16	25%

BLACK STAIN ROOT DISEASE IN THE PINYON - JUNIPER WOODLANDS OF SOUTHWESTERN COLORADO

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Pinyon-juniper woodland is the largest forest cover type in Colorado, covering over 1.8 million ha. Reports of pinyon pine (*Pinus edulis*) dying in unprecedented numbers have made pinyon mortality a top priority for land managers in southwestern Colorado. Substantial increases in use of pinyon - juniper woodlands for housing and recreation in recent years has turned this problem into a regional issue. Primary mortality agents associated with increased pinyon mortality are black stain root disease (BSRD) and Ips bark beetles. Black stain root disease is a vascular wilt disease of pinyon pine caused by the native fungal pathogen *Leptographium wageneri* var. *wageneri* (Kendr.) Wingf.

In the summer of 1999, a study was undertaken to examine BSRD caused discrete areas of mortality (mortality centers) in pinyon - juniper woodlands in SW Colorado. The effects of BSRD on the composition and structure of pinyon - juniper woodlands at the tree, shrub, and herbaceous plant levels and on tree seedling regeneration were assessed. Thirty discrete BSRD mortality centers were examined, with three transects established within each center. For every tree within each transect we recorded location, species, height, diameter at root crown, tree status, decline agents, and presence of black stain and Ips. Shrub and seedling plots of 40 m^2 were established at the mid-point of the transect and 9.14 m beyond the transect in which the percent shrub cover by species and the number of tree seedlings were recorded. Two - twenty by fifty centimeter plots were established at both the mid-point of the transect and 9.14 m beyond the transect in which the percent herbaceous cover by species and the percent cover by bare soil, litter, and rock were recorded. Discrete BSRD mortality centers had a mean area of 0.28 ha and a mean ratio of perimeter to area 3.3 times higher than a perfect circle indicating they were not expanding evenly in all directions. Mortality centers contained both pinyon regeneration and surviving pinyon. The majority (68%) of all pinyon was dead; 76% of pinyon were affected by BSRD and 70% had evidence of Ips bark beetle attack. BSRD significantly affected both the structure and composition of the woodlands, reducing live pinyon density by 63% and creating stands dominated by pinyon snags and logs. BSRD through removal of the pinyon overstory did not significantly impact shrub composition, percent cover, or diversity. Herbaceous percent cover was significantly higher within mortality centers and frequency responses were species specific. Pinyon regeneration was not significantly altered; and juniper regeneration was significantly higher within mortality centers than surrounding areas.

To determine the viability of the pathogen in the roots of dead pinyon, root samples taken from older dead pinyon were isolated from in the laboratory. To determine the length of time pinyon snags and logs persist to provide habitat, erosion protection, and other ecosystem properties, tree cores and/or stem cross-sections were obtained from sound pinyons in all represented tree classes, mounted, sanded, and cross-dated to determine year of mortality. The pathogen was regularly isolated from pinyon roots dead for 5 to 8 years and, once, from the root of a pinyon estimated to have been dead for 16 years indicating that the pathogen may persist on site to infect subsequent pinyon populations. The oldest dated pinyon mortality had been dead for 26 years, indicating that mortality within these discrete centers had occurred recently. The

breakdown of pinyon snags and logs was rapid; the oldest datable pinyon status class had been dead for an average of 16.2 years pinyon. Pinyon snags may persist for up to 25 years.

To determine the rate at which discrete BSRD mortality centers are expanding and whether this rate is influenced by site characteristics, data on distance between pinyons and their respective years of mortality were analyzed. The rate of expansion of mortality was variable between the 30 BSRD centers, but averaged 1.1 m/yr and had a maximum rate of 2.0 m/yr. The rate of mortality center expansion was not significantly effected by available water capacity, percent organic matter, or pH of soils; pinyon density; nor any other site data recorded.

Evaluation of *Colletotrichum gloeosporioides* as a biocontrol agent for lodgepole pine dwarf mistletoe under field conditions

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A field trial was established in the summer of 2000 to assess the efficacy of *Colletotrichum gloeosporioides* (Penz.) Penz. & Sacc. as a biological control agent for *Arceuthobium americanum* Nutt. ex Engelm parasitizing *Pinus contorta* Dougl. ex Loud. var. *latifolia* Engelm. Five treatments were applied as follows: 1. *C. gloeosporioides* formulated in Stabileze sprayed to run-off, 2. *C. gloeosporioides* formulated in Stabileze applied to cut shoots, 3. A mycelial plug of *C. gloeosporioides* applied to an artificial wound on the dwarf mistletoe swelling, 4. Sterile Stabileze sprayed to run-off, 5. No treatment, check. Of the 45 replicates per treatment, 22 were enclosed within clear polyethylene bags for 48 hours post inoculation (PI) to provide increased humidity. Vigour and disease rating scales were developed and recorded at 2-, 4-days, 1-, 2-, 3-, 4-, 5-weeks, 2-, 8-months and 1-year PI to assess the effect of inoculation. Chi-square analysis indicated that disease rating was independent of the presence of the plastic bag. Analysis of variance on ranks was used to determine if significant differences existed between treatments. At 2-months PI, the disease rating of treatments 1 and 2 were significantly higher than the controls; however, at 1-year PI, there was no significant difference between treatments. The vigour rating of treatment 2 was significantly lower than the other treatments at 2-months and 1-year PI. The change in the number of fruit present on each infection 1-year PI was compared by the Mann-Whitney rank sum test and treatment 2 and 3 had significantly less fruit, compared to pre-inoculation, following fungal application; treatments 1, 4 and 5 did not. The average number of fruit present on treatment one was reduced, but the variability was very high (-49.8 ± 47.7, mean ± S.E. of the mean), resulting in no significant difference. The fungus became established and affected fruit production, therefore interfering with seed dispersal by *A. americanum*. The decrease in disease rating of dwarf mistletoe inoculated with treatments 1 and 2 at 1-year PI is likely a result of shedding dead shoots, thereby reducing the percent infection of *A. americanum* by *C. gloeosporioides*.

Western hemlock dwarf mistletoe: effects on branch morphology and physiology

Morgan Dutton[1], Tom Hinckley[1], Dave Shaw[1], and Nathan Phillips[2]

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Host-parasite relationships between the hemlock dwarf mistletoe (*Arceuthobium tsugense spp. tsugense*) and western hemlock (*Tsuga heterophylla*) were investigated at the Wind River Canopy Crane Research Facility. Phloem and xylem of the western hemlock are tapped by the mistletoe, thus removing water, nutrient and photosynthate resources from the host. This parasitism should reduce host vigor and growth.

Methods: 3 large infected (damage rating > 3) & 3 large uninfected, old-growth western hemlock trees were studied. Branches were in the upper quarter of the crown. Twig samples from branch came from three locations: (1) near the stem [C], (2) at the infection point [B], & (3) near the tip (A).

Heights of infected and uninfected trees were not statistically different: Branch autonomy may reduce the negative impacts of mistletoe to a localized scale.
Infection, especially severe infection, may have occurred after the trees had accumulated most of their height growth

Summary of observations for infected branches: Foliage was lighter in color and had a greater yellow hue particular at positions B and A. Nitrogen was lower at positions B and A as compared to C or all positions on an uninfected branch. $\delta^{13}C$ values were lower (more negative) at positions B and A versus C or all positions on the uninfected branch. Needles were smaller at all positions. Differences in chlorophyll a, b and total were not detectable.

Western Nursery Pathology Workshop

Submitted by Diane Hildebrand

The 20th annual Nursery Pathology Workshop was held in conjunction with WIFDWC on Monday, September 10, 2001, from 12:30 pm to 5 pm. Approximately a dozen participants included state, federal, and industrial forest pathologists involved in forest tree nurseries, and other interested individuals.

For the WIFDWC proceedings this year, the Disease Control Committee requested a summary of the information shared by participants (attending or *in absentia*). The updated Nursery Pathology Mailing List was sent electronically to each participant who provided an e-mail address.

NEWS AND NOTES

Kasten Dumroese, PhD, formerly of University of Idaho, Moscow, is now working for the USDA Forest Service (USFS), Southern Research Station, as a Plant Physiologist in Jim Barnett's project. Kas is still stationed in Moscow, Idaho, and is the editor of the *Native Plants Journal*. Bob James and Kas are in the process of getting their paper, on their five-year study of hot water and copper treatments for containers, published in *HortScience*.

Tom Landis reports that two of the classic nursery pathology publication are now available on-line:
Forest Nursery Pests, USFS Agriculture Handbook 680, and *Growing Healthy Seedlings*, USFS and Oregon State University, August 1990. The on-line address is the website for Reforestation, Nurseries, and Genetic Resources: http://www.rngr.fs.fed.us/nurseries/publications.html.

Fifth meeting of **IUFRO Working Party S7.03.04, Diseases and Insects in Forest Nurseries**, will be held May 7-9, 2002 at the Kerala Forest Research Institute (FRI) in Kerala, India. The FRI has an impressive list of achievements and services related to natural resources. The website for the working party is http:iufro.boku.ac.at/iufro/iufronet/d7/hp70304.htm.

REPORTS

Cypress Canker on Port-Orford-Cedar

Katy Marshall, USFS, Southwest Oregon Forest Insect and Disease Service Center, Medford, OR

In November 2000, Cypress canker was identified on Port-Orford-cedar seedlings at the Dorena Genetic Resource Center in Cottage Grove, Oregon. This disease is caused by the fungus, *Seiridium cardinale*. Initial symptoms of the disease included dieback of branches and copious resin flow from sunken cankers on the boles. In many cases the infection court appears to have been at the point where small branchlets join the bole. Some of the cankers eventually became large and swollen, with broken bark. Mortality has occurred in some severely infected trees due to mechanical failure of the bole at the canker site.

The literature is unclear as to whether Port-Orford-cedar is a host in natural stands within its range. The disease is common on off-site Monterey cypress in California, in plantations of Leyland cypress grown for Christmas trees in the southeastern United States, on Port-Orford-cedar in New Zealand, and on several species of cypress in the Mediterranean. Right now it is not clear whether this disease is native to the area or was brought in on seedlings or cuttings,

possibly from California. All of the affected seedlings had been stored outside at Dorena during one winter. Later it was discovered that a group of seedlings previously brought from California and planted in outdoor raised beds were heavily infected, as were large natural incense cedars and one planted Leyland cypress on the lawn of the Center. On the Leyland cypress the fungus appears to be causing foliar infections, and producing many fruiting bodies. It may be a source of large amounts of inoculum.

All visibly infected seedlings in the greenhouses were destroyed in Fall 2000. Dorena personnel have been treating the remaining seedlings on an experimental basis with chlorothalonil to prevent infection based on research by McCain (1984, Journal of Arboriculture). They are planning to initiate additional trials this fall to test the efficacy of several other fungicides to control this disease.

Current Projects:

R.L. James, USFS, Northern Region, Forest Health Protection (FHP), Coeur d'Alene, Idaho

1. Alternatives to pre-plant soil fumigation at USFS Coeur d'Alene and Lucky Peak nurseries.
   a. Evaluate biological control formulations of *Trichoderma harzianum* as well as bio-fumigation using new varieties of *Brassica* spp. (in cooperation with the University of Idaho).
   b. Continue evaluating alternative chemical fumigants at the Lucky Peak Nursery (dazomet is the operational fumigant at Coeur d'Alene Nursery).
2. Refine sanitation treatments of reused styroblock containers in container nurseries (in cooperation with USFS. Missoula Technology & Development Center). Evaluate radio frequency waves and dry heat treatments.
3. Evaluate efficacy of commercially-available biological control treatments to control soilborne pathogens in container and bareroot forest nurseries.

Recent Publications:

R.L. James, USDA Forest Service, Northern Region FHP, Coeur d'Alene, Idaho

1. Dumroese, R.K., R.L. James and D.L. Wenny. 2000. An assessment of *Cylindrocarpon* on container western white pine seedlings after outplanting. West. J. of Appl. For. 15(1): 5-7.
2. James, R.L. 2000. Diseases associated with whitebark pine seedling production - Coeur d'Alene Nursery, Idaho. USFS, Northern Region, FHP Report 00-8. 11p.
3. James, R.L. 2000. Effects of a 2-year fallow period on soil populations of *Fusarium*, *Trichoderma* and *Pythium* species after incorporating corn plant residues - Coeur d'Alene Nursery, Idaho. USFS, Northern Region, FHP Report 00-17. 11p.
4. James, R.L. 2000. Effects of topical application of the biological control agent Biotrek® on production of bareroot Douglas-fir and western white pine seedlings - Coeur d'Alene Nursery, Idaho. USFS, Northern Region, FHP Report 00-5. 8p.
5. James, R.L. 2000. Root diseases of bareroot western larch seedlings - Coeur d'Alene Nursery, Idaho. USFS, Northern Region, FHP, Nursery Disease Notes No. 141. 9p.
6. James, R.L. 2001. Fungal distribution within plastic super cell®containers - Lucky Peak Nursery, Boise, Idaho. USFS, Northern Region, FHP, Nursery Disease Notes No. 145. 7p.
7. James, R.L. 2001. Outbreak of *Sirococcus strobilinus* on 2-0 ponderosa and lodgepole pine seedlings - Coeur d'Alene Nursery, Idaho. USFS, Northern Region. FHP, Nursery Disease Notes No. 142. 7p.
8. James, R.L. 2001. Phytophthora blight of container-grown *Ceanothus* seedlings at Coeur d'Alene Nursery, Idaho. USFS, Northern Region, FHP, Nursery Disease Notes No. 143. 10p.
9. James, R.L. 2001. Root disease of 1-0 bareroot Douglas-fir seedlings - Lucky Peak Nursery, Boise, Idaho. USFS, Northern Region, FHP, Nursery Disease Notes No. 144. 10p.

10. James, R.L. and K. Beall. 2000. Effects of fallowing on *Fusarium*-associated root diseases and production of bare root ponderosa pine seedlings at Lucky Peak Nursery, Boise, Idaho. USFS Northern Region, FHP Report 00-3. 13p.

IR4 Fungicide Testing For Botrtyis Control, Preliminary Results.

Will Littke and **John Browning**, Weyerhaeuser Forestry R&D, Centralia, WA.
Bob Lindermann, USDA Agricultural Research Service (ARS), Corvallis. OR
Robert Lambe, Hood's Canal Nursery, Port Gamble, WA.

IR-4 considers minor use testing and clearance for new pesticides. Many of the long term fungicides currently being used show reduced efficacy against established Botrytis strains. New novel fungicide/biocontrol agents are coming on the market to replace those agents that are being removed or have lost their efficacy.

A series of in-vitro growth inhibition test have been completed prior to this falls screening in the greenhouse. Isolates of *Botrytis cinerea* were collected from diseased seedlings, root isolation, seed, and from storage problems at several nurseries : (WA) Hoods Canal, Rochester, Mima, (OR) Turner, and Aurora. Isolates were grown on PDA agar (control) or fungicide amended PDA media at 25C. Measurements of colony diameter growth inhibition were made after 2-weeks.

Variation in fungicide tolerance was found amongst the isolates taken from several conifer container nurseries: This reinforces the need to have a rotation of fungicides with different modes of action. A new fungicide: Compass did not severely inhibit growth of the Botrytis isolates. A further fungicide concentration series (200 ppm, 600 ppm, and 1200 ppm A.I.) was prepared on several additional chemicals:

Trifloxystrobin- Compass 50W (Bayer)
Rapsody BioFungicide- Bacillus subtilis (AgraQuest)
Fenhexamid- Decree 50WDG (Sepro Corp)
Cyprodinil+Fludioxonil - Switch (Syngenta)
BASF 516

The preliminary results suggest some viable candidates (BASF-516, Switch, and Decree) to replace the fungicides with resistance buildup, however Compass and Rapsody do not appear to be effective or have problems with uniformity of action. Green house testing (Lambe) to take place in a Botrytis augmented environment (spores to be added from the isolates taken from the previous crop) followed by application of various chemicals at 1X, 2X and 4X recommended rates. Phytotoxicity is being investigated by Lindermann at ARS. Caution should be taken in the interpretation of results from media amended fungicide trials, since pathogen response to foliar applications might be different.

Alternatives to Methyl Bromide Soil Fumigation.

Will Littke and **John Browning**, Weyerhaeuser Forestry R&D, Centralia, WA.

Efforts continue on testing of various soil chemical fumigant treatments as alternatives to MB. Some of these new trials include evaluation of dramatic reductions in the concentration of MB from 67:33 (Chloropicrin) or 98: 2 (Chloropicrin) to 50:50 or 45:55 (Chloropicrin), or substitution of MB for straight 100% Chloropicrin, Telone 75: 25 (Chloropicrin), or combinations of Chloropicrin, Telone, and Metam-Sodium (TriFume 35).

Previously, we completed several multiyear (3-crop years') field validation trials using Chloropicrin, Telone/Chloropicrin, and Metam-Sodium as substitutes for MB in several Southern nurseries in Oklahoma, Arkansas, North Carolina and South Carolina. These results suggest that Chloropicrin at 200 lbs/ac could produce similar disease control efficacy as MB against Fusarium and Pythium. However, this fumigant does not control weeds as well and is overall not effective

against nut-sedge grasses. Mixtures of Telone (a nematicide) and Chloropicrin show promise as well as a good overall soil fumigant. Metam-Sodium has always tested slightly lower in efficacy and reliability to the other alternative fumigants.

In 2001, trials are underway at Magnolia, AR and Washington, NC to evaluate Chloropicrin and Telone/Chloropicrin for soil disease control, but also to further evaluate their weed control potentials. Fall 2000 post-fumigation samples showed nearly 100% removal of Fusarium soil propagules (0-12 inch depth) in all replicate treatments of MBC (98:2), Chloropicrin (100%), and Telone/Chloropicrin (75:25). Seedling root isolations taken in July show little Fusarium root infection between treatments or nurseries. Additional post-season pathology and morphology samples will be taken at lift (Jan 2002).

Mima nursery in Washington, is currently testing 50:50 MBC in seedbed 1-DO Douglas-fir against the current standard of 67:33 MBC. Results so far show no statistical difference in disease control, seedling density, or quality. A study of MBC (67:33), Chloropicrin (100%), and Telone/Chloropicrin (75:25) is underway in 1+1 Douglas-fir transplant beds. Post fumigation soil sampling showed no difference in efficacy when these three fumigants were applied in the fall.

Evaluations for effective alternatives to methyl bromide need to consider secondary pathogens (Cylindrocarpon sp.) and other pathogens that might no be picked up on the standard assay tests for Fusarium or Pythium. Weed control may become the most important pest management problem in the post-MB era.

Cylindrocarpon didymum-A New Pathogen or Secondary Root Colonizer?

Will Littke and **John Browning**, Weyerhaeuser Forestry R&D, Centralia, WA.

In 2001, several plantation Douglas-fir bare-root reforestation problems erupted in WA and OR after a cold and droughty winter and spring. *Cylindrocarpon didymum* and potentially other *Cylindrocarpon* species were routinely isolated from failing seedlings, in levels that would lead some to believe could be pathogenic.

There has been a lot published on *Cylindrocarpon destructans* as a seedling pathogen, storage decline pathogen, and in causing plantation failures of container seedlings. Less has been reported about *C. didymum* and its ability as a pathogen.

Cylindrocarpon is routinely isolated from bare-root and container seedlings as a consequence of isolation of *Fusarium* species using Komada's media. In most instances *C. didymum* occurs in association with other nursery pathogens such as Fusarium and Pythium. It's ability to grow at lower temperatures (0-3C), tolerance of commonly applied fungicides (Ferbam, Daconil, Chipco 20619), and in adverse soil physical environments (flooded soils, compacted areas) increases the possibility that *C. didymum* may a be pathogen under specific circumstances.

Root fragments sieved from soils in a 1-year follow field were found to harbor *C. didymum* at levels of 0-50%, but could not be recovered from similar roots 1-month post MBC fumigation. Soil propagule counts of *C. didymum* are not reliable given competition by other fungi, however the suggestion of incubation of soil plates at lower temperature to selectively isolate this fungus have not yet been tested. Root fragments from lifting boxes used the previous crop season were also shown to be infected with this fungus. These findings indicate that *C. didymum* may be able to sustain itself and to re-infest soils and seedlings from previously infected materials. This fungus produces abundant chlamydospores when grown on PDA.

Isolates of *C. didymum* are currently being evaluated for their ability to cause root mortality on lifted 1+1 DF. Other tests are being conducted to evaluate fungicide or biological disease control options in bare-root and container crops. Thanks to Dr. Jeff Stone at Oregon State University for identification of *Cylindrocarpon didymum*.

Field B Demonstration, Comparison of Grass Cover Crops, Bare Fallow, and Dazomet Fumigation at J. Herbert Stone Nursery, 1997-1999.

Diane M. Hildebrand, USFS, Portland, OR, and **Jeffrey K. Stone**, Oregon State University

This demonstration compared the effects of grass cover crops, bare fallow, and fumigation, as pre-plant treatments, on density and size of conifer seedlings. As a demonstration, treatments were implemented in large blocks, without replication. Based on measurements of seedling density, diameter, and height, trends in the data suggested that for Douglas-fir, ponderosa pine, and lodgepole pine, the best treatment was bare fallow with dazomet. Trends also suggested that rye cover crop with dazomet was among the best treatments for Douglas-fir. Sudan cover crop with dazomet tended to be the best treatment for Shasta red fir. Disease pressure in Field B was fairly low, as usual for this Field.

Current Projects

Diane M. Hildebrand, USFS, Portland, OR

1. Alternatives to Fumigation trial, implemented in Field K at J. Herbert Stone Nursery, 1999-2001, in a randomized block design, with six Blocks, tests four pre-plant treatments for four conifer species. Treatments include grass cover crop with and without dazomet fumigation and bare fallow with and without dazomet fumigation. Because of soil characteristics, some disease pressure is expected, based on past experience with conifers in this field. With six replications, this field trial may provide useful data on the relationship of fungal pathogen population levels and disease in conifer seedlings at the nursery.
2. Alternatives to Fumigation trial, implemented in Field B at J. Herbert Stone Nursery, 2000-2002, in randomized blocks of bare fallow and dazomet fumigation. The blocks are split for comparison of four fertilizer treatments for Douglas-fir, incense cedar, noble fir, and ponderosa pine, and for comparison of soil amendments (medite and sawdust) for Douglas-fir, noble fir, and ponderosa pine. Medite is a by-product of a local wood-fiber industry and is readily available to the nursery.

COMMITTEE REPORTS

Dwarf Mistletoe Committee Report

Submitted by Katy Marshall

I. TAXONOMY, HOSTS, AND DISTRIBUTION.

a) Our work on the taxonomic status of the shore pine dwarf mistletoe is continuing. We now have a draft of a manuscript prepared and plan to submit it for publication soon. (E. Wass, Canadian Forest Service, PFC, Victoria, B.C.; R. Mathiasen, Northern Arizona University, Flagstaff, AZ).

b) Further observations of the phenology of Hawksworth's dwarf mistletoe *(A. hawksworthii)* were made in early November 2000 in Belize. The female plants were not quite ready to disperse seeds, but fruits could be squeezed out of their pericarps. Therefore, it appears that seeds are dispersed from late November into December for *A. hawksworthii.* Male plants were not flowering in early November. (R. Mathiasen, Northern Arizona University, Flagstaff, AZ).

c) A small population of large stemmed dwarf mistletoe (*A. globosum* ssp. *grandicaule*) was discovered on *Pinus hartwegii* in November 2000 at the summit of Cerro las Minas in Celaque National Park near Gracias, Department Lempira, Honduras. This is the first report for this dwarf mistletoe from Honduras and extends its distribution by approximately 300 km to the east from west-central Guatemala. (R. Mathiasen and B. Howell, Northern Arizona University, Flagstaff, AZ; J. Melgar, ESNACIFOR, Siguatepeque, Honduras).

d) Our field observations "suggest" that the Honduran dwarf mistletoe (*A. hondurense*) which was recently found in Chiapas, Mexico may also be present in Oaxaca, Mexico. A dwarf mistletoe strongly resembling *A. hondurense* was collected near Suchixtepec in December 2000. We are in the process of completing the molecular analysis of this collection in order to confirm that it is *A. hondurense* or not. (R. Mathiasen, Northern Arizona University, Flagstaff, AZ; D. Nickrent, Southern Illinois University, Carbondale, IL).

e) Specimens of Oaxacan dwarf mistletoe (*A. oaxacanum*) were collected from the type locality in Oaxaca, Mexico in December 2000. We are in the process of sequencing the ITS regions of the ribosomal DNA cistron for this species. Oaxacan dwarf mistletoe is one of the few dwarf mistletoes that has not yet be analyzed using molecular techniques. (D. Nickrent, Southern Illinois University, Carbondale, IL; R. Mathiasen, Northern Arizona University, Flagstaff, AZ).

f) In the never-ending quest for the World's largest dwarf mistletoe, our latest trophy-hunting expedition found us exploring the dangerous slopes of Nevada de Colima, Jalisco, Mexico in January 2001. A male plant of Mexican dwarf mistletoe (*Arceuthobium vaginatum* ssp. *vaginatum*) measuring **92.5 cm** in height was discovered on *Pinus hartwegii* at an elevation of nearly 11,000 feet. This represents the largest dwarf mistletoe plant discovered, thus far, in the Universe. The old record, held by *A. globosum* ssp. *grandicaule,* from Guatemala was 81 cm. More dwarf mistletoe trophy hunting in Guatemala is scheduled for December 2001. We anticipate that a male dwarf mistletoe plant will eventually be discovered that exceeds one meter in length! (R. Mathiasen and C. Daughety, Northern Arizona Univ., Flagstaff, AZ; Jaime Villa,

Ciudad Obregon, Jalisco, Mexico).

g) We published a technical note in the Western Journal of Applied Forestry (Vol. 16, No. 2) on the susceptibility of foxtail and western white pines to limber pine dwarf mistletoe (*A. cyanocarpum*). Foxtail pine remains classified as an occasional host and western white pine is a secondary host for this dwarf mistletoe in northern California. No infection by limber pine dwarf mistletoe was observed on Low's fir or Jeffrey pine during the study. (R. Mathiasen and C. Daugherty, Northern Arizona University, Flagstaff, AZ).

h) The juniper dwarf mistletoe, *Arceuthobium oxycedri*, is the dwarf mistletoe with the longest taxonomic history and greatest geographic range. We have published the results of a several year effort to update information on the hosts and distribution of this mistletoe as Research Note RMRS-RN-11 (Ciesla, Geils, and Adams at http://www.fs.fed.us/rm/pubs/rmrs_rn11/index.html. We recognize 26 host species and map the distribution for 30 countries from North Africa, Europe, Indian subcontinent, and Asia. (B. Geils, Rocky Mountain Research Station, Flagstaff, AZ; W. Ciesla, Forest Health International, Fort Collins, CO; R. Adams, Bishop Museum, Honolulu, HI).

i) Work is now proceeding well to catalog the mistletoe collection of the Forest Pathology Herbarium (FPF). This collection was assembled by Frank Hawksworth and Del Wiens to support their research on mistletoe taxonomy, hosts, and distribution. To maintain good curation of the collection, specimen sheets are being dispersed to several herbaria, primarily the US National Herbarium and the UC Herbarium at Berkeley, CA. When the project is completed later this year, I intend to publish a report identifying which institution has received each of the 5,000 accessions. (B. Geils, Rocky Mountain Research Station, Flagstaff, AZ).

II. PHYSIOLOGY AND ANATOMY

a) Fredrick Meinzer and David Shaw have begun a research project based at the Wind River Canopy Crane on the, "Impact of Dwarf Mistletoe on the Hydraulic Architecture and Whole-Tree Water Relations of Western Hemlock". In this study, a variety of approaches (including whole tree sapflow, leaf water potential, stomatal conductance, N, leaf area, conductance of basal segments) will be employed to characterize the impact of dwarf mistletoe infection on the hydraulic architecture and water relations of western hemlock over a range of scale from leaf to whole-tree. (F. Meinzer, USFS, PNW Research Station, Corvallis and D. Shaw, Wind River Canopy Crane Research Facility, University of Washington).

III. LIFE CYCLES

a) Our study of the sex ratio for Chihuahua pine dwarf mistletoe (*A. gillii*) is completed. We sampled an additional population of *A. gillii* in the Sierra Madre Occidental near the Sonora-Chihuahua state line in June 2001. So far the sex ratio of all the populations we have sampled is essentially 1:1. We plan to submit a manuscript to Madrono in the near future. (R. Mathiasen and C. Daugherty, Northern Arizona University, Flagstaff, AZ).

b) Although Hawksworth and Wiens (1996, see page 258) speculated that Yecoran dwarf mistletoe (*A. yecorense*) flowers in June, our observations from June 25-27, 2001 in Sonora and Chihuahua, Mexico indicated that no male flowers were near anthesis. We now estimate that this species flowers from sometime in late July through August, perhaps into September. The period for seed dispersal for *A. yecorense* remains unknown. (R. Mathiasen and C. Daugherty, Northern Arizona University, Flagstaff, AZ).

IV. HOST-PARASITE RELATIONS

a) Now that we have a greenhouse full of host trees suitable for inoculation, we will begin the pathology phase of a study on the ecophysiology of mistletoe latency. This cooperative study of the Rocky Mountain Research Station and Northern Arizona University will examine the effects of water stress and of shading on mistletoe incubation, reproduction, and latency. Species under study are hemlock dwarf mistletoe, Douglas-fir dwarf mistletoe, lodgepole pine dwarf mistletoe, and southwestern dwarf mistletoe. We hope to better understand the physiology behind resurgence of mistletoe populations after partial stand opening. (B. Geils, Rocky Mountain Research Station, Flagstaff, AZ; T. Kolb, Northern Arizona University, Flagstaff, AZ).

V. EFFECTS ON HOSTS

a) The Southwest Oregon Forest Insect and Disease Service Center and Medford District, Bureau of Land Management, are conducting a study to examine the sequence of development of dwarf mistletoe brooms on Douglas-fir. We would like to know whether big brooms are old, whether brooms develop continuously during the life of the trees and whether trees infected early in life survived to become large in size. In the first part of the study, thirty large Douglas-fir were felled and each branch examined for infection. We collected data on the ages of the trees, infected branches and mistletoe brooms; characterized the brooms using Tinnin and Knutson's three broom types; and measured the brooms' volume, distance from the bole and height from the ground. The data will be analyzed this winter. In the second part of the study we will select small trees, monitor them for the initiation of new infections and collect data on the early development of the brooms. We hope to use this information to make recommendations about how to grow large Douglas-fir with large mistletoe brooms suitable for wildlife use. (K. Marshall and D. Goheen, SWOFIDSC, and D. Russell, Medford BLM).

VI. ECOLOGY

a) The objective of this research is to determine the relationship between avian relative abundance and species diversity, and infestation by Southwestern dwarf mistletoe (*A. vaginatum* subsp. *cryptopodum*) in ponderosa pine forests of northern Arizona. We hypothesized that birds occur in greater abundance and with wider species diversity in stands that are infested with dwarf mistletoe compared to similar non-infested stands. The fixed radius point-count method was used to determine an index of relative avian abundance and species diversity within stands of varying mistletoe infestation severity. Twenty 80-acre study sites were selected in pure pine forests west of the San Francisco Peaks in the Coconino National Forest. Five study sites in each of the following classes were selected: 1) severely infested (mean DMR > 2.0); 2) moderately infested (mean DMR 1.1-2.0); 3) lightly infested (mean DMR 0.1-1.0); and 4) uninfested (mean DMR 0). Eight point-count stations have been established within each stand. Birds were sampled at each point count station 6 times in 1999, and 6 times in 2000. Detailed stand characterization was completed in 40 0.1-acre plots within each stand. Each tree encountered was rated for dwarf mistletoe infection using Hawksworth's dwarf mistletoe rating, Tinnin's broom volume rating, % volume broomed, and an absolute broom volume rating. In addition, ground cover, shrub/sapling cover, canopy structure, and coarse woody debris data were collected to identify potential covariates. It is our goal to quantify how several avian species respond to different levels of dwarf mistletoe infestation and to recommend what levels of mistletoe infestation might be most beneficial to birds. Data are being analyzed at this time. (T. Parker, R. Mathiasen, and C. Chambers, Northern Arizona University, Flagstaff, AZ).

b) We investigated bird and mammal use of Douglas-fir dwarf mistletoe-induced witches' brooms in the Southwest. There were two phases of the study. The first phase was a comparison of wildlife use in broomed and unbroomed trees. Three stands were selected on the San Francisco Peaks on the Coconino National Forest in Northern Arizona. We laid out 4x4 grids (each point 80.5m apart) in each stand and systematically selected pairs of broomed and unbroomed trees (based on diameter at breast height) at each point to climb. We climbed trees in these stands in the fall of 1998 and 1999. We have found significantly more use in the broomed trees versus the unbroomed trees. Due to what appears to be preferential use of broomed trees by birds and mammals in these areas, a second phase was added to the study in order to increase the scope of inference. During the summer of 1999, 5 transects on 4 national forests in Arizona and New Mexico were randomly selected. Fifteen broomed trees (5 trees in 3 diameter classes) on each transect were systematically selected and climbed to examine for wildlife use. Red squirrels were the primary mammal to use witches' brooms in Douglas-fir in the Southwest. A masters thesis by Shaula Hedwall was completed in May 2000. We have submitted a manuscript to the Journal of Wildlife Management. (S. Hedwall, C. Chambers, R. Mathiasen, Northern Arizona University, Flagstaff, AZ; S. Rosenstock, AZ State Fish and Game, Flagstaff, AZ; B. Geils, RMRS, Flagstaff, AZ; M. Fairweather, FHP, R3, Flagstaff, AZ; and C. Parks, PNWRS, LaGrande, OR).

c) We are progressing into the second field season (2001) of our study examining wildlife use of witches' brooms in ponderosa pine in northern Arizona. The first field season (2000) involved locating study sites and selecting sample trees. This is a continuation of work on wildlife use of witches' brooms in Douglas-fir. (G. Garnett, R. Mathiasen, and C. Chambers, Northern Arizona University, Flagstaff, AZ).

d) **Potential impacts of herbivory on hemlock dwarf mistletoe.** We are beginning a research project on herbivores of hemlock dwarf mistletoe. We will be proposing a project centered at the Wind River Experimental Forest that will investigate the herbivores and their potential impacts on population control of mistletoe, i.e. does herbivory influence the spread and intensification of hemlock dwarf mistletoe? Initial observations suggest the mistletoe hairstreak is a common herbivore at this site, and we may do some additional work determining life cycle and ecology of this unique butterfly. (K. Ernest, Central Washington University and D. Shaw, Wind River Canopy Crane Research Facility, University of Washington).

e) We have developed a theory, presented at Northwest Scientific Association conference in Arcata, Calif. in March 2001. **We hypothesize that western hemlock dwarf mistletoe, a parasite of a secondary successional species, is maintained on the landscape in the Douglas-fir region by** 1. Survival of small clusters of infected hemlock trees that persist after stand replacement disturbances such as fires. These small clusters become the center of expanding infection centers as the surrounding forest changes from dominance by Douglas-fir to dominance by western hemlock. 2. Large scale refugia (200 ha +) that are only partially disturbed during major stand replacement disturbances. An example of a refugia exists on Trout Creek Hill, Wind River Experimental Forest (WREF). The infection center exceeds 300 ha and may be associated with poor soils and an especially low productivity site. The tree density on the site is low, shrub dominance is high, and every western hemlock is heavily infected with dwarf mistletoe. Perhaps fire does not carry well in this open canopy forest, and therefore, dwarf mistletoe persists indefinitely, never being totally eradicated. 3. Spread from refugia and infection centers is primarily a result of small scale dispersal from female plants, but on occasion, new infection centers develop from seed passively dispersed by birds (such as Stellar's Jay, Gray Jay, and Red Crossbill). We hope to test this hypothesis in a chronosequence of forest age classes on the WREF. (D. Shaw, Wind River Canopy Crane Research Facility, University of Washington and J.

Beatty, USDA Forest Service).

f) Studies of interactions among plants, microbes, and the soils they inhabit are critical to our understanding of ecosystem function, and hence our ability to successfully manage forested wildlands. We propose to use molecular-genetic methods to determine the effects of dwarf mistletoe infection of *Pinus contorta* in ectomycorrhizal (EM) communities in pure *P. contorta* and mixed *P. contorta/Picea engelmannii* stands. We will do so across a soil fertility gradient created by a transition from relatively nutrient-rich andesite, through a transition zone created by glacial activity, to nutrient-poor rhyolite. We will be the first to investigate alteration of carbon flow to roots and the effect this has on EM communities in a mixed tree species forest, and the first to combine these factors with soil fertility and plant pathogen infection. Using molecular methods, we will provide a more comprehensive picture of this aspect of ecosystem function than was previously possible without them. We will conduct this study in Yellowstone National Park, the centerpiece of the 11 million acre Greater Yellowstone Ecosystem, which includes several National Forests in three states. Thus we will add greatly to our understanding of a pristine, economically important, and geographically dominant ecosystem (K. Cullings, NASA-Ames Research Center, Mountain View, CA and D. Vogler, Institute of Forest Genetics, PSW Research Station, Davis, CA).

g) A cooperative study of the University of Colorado and Rocky Mountain Research Station is in progress to investigate the effects of multiple predators on ponderosa pine canopy herbivores and dwarf mistletoe demography. Field studies and experiments by Kailen Mooney have been completed or are still underway at the Manitou Experimental Forest. Kailen is investigating the effects of dwarf mistletoe on the canopy arthropod community and the interactions of birds and ants on predation and herbivory in mistletoe-broomed ponderosa pine. Early results confirm that mistletoe shoots are usually subject to herbivory (but consequences difficult to quantify) and that the composition of the arthropod community is affected by mistletoe, birds, and other arthropods. (B. Geils, Rocky Mountain Research Station, Flagstaff, AZ.; Y. Linhart and K. Mooney, University of Colorado, Boulder).

VII. GENETICS

a) In 1997, a dwarf mistletoe resistance test plantation was established at the Badger Hill Breeding Arboretum near Placerville, California. Ponderosa pine seedlings for this test are from resistant candidates selected on the Lassen and Plumas National Forests, heavily infected controls selected on these two forests, and controlled pollination seeds from six suspected resistant clones at the arboretum. Block 1 of this test plantation was used to test the effects of inoculation timing and protection from bird predation. Inoculation with dwarf mistletoe seed in December 1999 resulted in 84% seed retention, 50% seed germination, and 25% penetration of the germ tube into branch tissue. Inoculation in March 2000 resulted in 75% seed retention, 13% germination, and 2% penetration. In the December inoculation, seedlings were covered with bird netting or bridal veil, or were left uncovered. Protection with bird netting yielded 82% seed retention, 47%, germination, and 26% penetration. Protection with bridal veil resulted in 87% seed retention, 51% germination, and 26% penetration. Uncovered seedlings had 83% seed retention, 52% germination, and 22% penetration. In the March inoculation, protection with bird netting resulted in slightly better retention, germination, and penetration than the uncovered controls. No bridal veil was used in March. Because the earlier inoculation produced much better germination and penetration, the remaining four blocks were inoculated in late November, 2000. The seedlings were left uncovered since there were no significant differences between the control and the protection treatments. (D. Ringnes, USDA Forest Service, R-5 Genetic Resources Program).

Ponderosa pine - Dwarf mistletoe resistance trial

Block 1 inoculation test Test of inoculation timing and protection from birds

Evaluated July, 2000

Rep #	Date Treated	Treatment	# Seed Placed	# Seed Retained	**Percent Retained**	# Seed Germinated	**Percent Germ**	# Seed Penetrated	**Percent Penetrated**
1	Dec. 1999	Control	135	112	**83**	70	**52**	30	**22**
2	Dec. 1999	Bird net	135	111	**82**	64	**47**	35	**26**
3	Dec. 1999	Bridal veil	135	118	**87**	69	**51**	35	**26**
4	Mar. 2000	Control	150	105	**70**	19	**13**	4	**3**
5	Mar. 2000	Bird net	110	91	**83**	16	**15**	2	**2**

VIII. MANAGEMENT

a) The Southwest Oregon Forest Insect and Disease Service Center is assisting the Applegate Ranger District, Rogue River National Forest with monitoring large Douglas-fir that have been pruned to remove branches infected with Douglas-fir dwarf mistletoe. The District would like information about the feasibility of pruning large Douglas-fir in forest stands to reduce the level of mistletoe; including the cost of pruning and subsequent fuels treatments, growth and survival of the pruned trees and the development of latent infections. Thirty-four Douglas-fir with DMR of 4 or less were selected for pruning in a stand designated for harvest. The remaining infected trees in the stand were cut. Thirty of the trees were recently pruned. In five years they will be re-examined. Trees with new infections will be pruned again if they have live crown ratios of at least 20 percent. (K. Marshall, SWOFIDSC and B. Thomas, Applegate RD).

b) A field trial was established in the summer of 2000 to investigate the efficacy of *C. gloeosporioides* as a biological control agent for *A. americanum*. Initial assessment of this trial is very encouraging. The disease rating of the dwarf mistletoe treated with the fungus was significantly higher than the controls. The one year post inoculation assessment is currently underway. The final assessment of experiments that were designed to model the effect of biological control treatment is also underway. These experiments are part of my Ph.D. research, which is supervised by Drs. Bart van der Kamp, University of British Columbia, and Simon Shamoun, Canadian Forest Service. (T. Ramsfield, University of British Columbia).

IX. SURVEYS

a) We have completed a roadside reconnaissance survey for pinyon pine dwarf mistletoe (*A. divaricatum*) in the pinyon-juniper woodlands of the Coconino National Forest in northern Arizona. We surveyed 220 km of roads representing pinyon pine woodlands in 24 Townships. Our results estimate that only about 12 percent of the area surveyed are infested with pinyon pine dwarf mistletoe. However, we probably have underestimated the amount of pinyon pine dwarf mistletoe present in the Coconino National Forest because of the difficulty of observing low levels of infection in pinyon pine using a roadside survey procedure. (R. Mathiasen and C. Daugherty, Northern Arizona University, Flagstaff, AZ).

X. MODELING

a) Several major steps have been achieved in the calibration and development of the Spatial-Statistical spread model (see Robinson, Geils, Muir, and Sutherland online presentation at http://www.essa.com/forestry/mistletoe). Spatial analyses of mapped stands and artificial landscapes conduced by J.J. Smith and B. Geils have revealed the range and behavior of key spatial parameters for stem clumping and infection autocorrelation. Realistic simulations can be generated for stands without the need for a detailed stem map if the general patterns can be matched to those of a reference stand. The model has been tested against the observed performance of a ponderosa pine stand in Arizona and used to evaluate novel, silvicultural treatments in coastal western hemlock stands. Progress is being made to adapt the model for simulating spread across distinct boundaries (such as from old-growth to young plantation) and for use with stand models (FVS) and with tree models (TASS). (B. Geils, Rocky Mountain Research Station, Flagstaff, AZ; J.J. Smith, Northern Arizona University, Flagstaff, AZ; D. Robinson, ESSA Technologies, Vancouver, BC; J. Muir, BC Ministry of Forests, Victoria, BC).

XI. MISCELLANEOUS

a) 2002 Cairns Conference: The 3rd International Canopy Conference will be held in Cairns, Australia in June of 2002. This conference will focus on a broad range of issues associated with biology, ecology and use of global forest canopies (web site: http://www.premiers.qld.gov.au/about/science/canopyconference/html/index.html). Of particular interest will be a symposium being organized by David Shaw and Bryan Barlow.entitled: **Macroparasites in the Canopy: Mistletoe Evolution and Ecology**. The proposed speakers include: Dan Nickrent, Job Kuijt, Gerhard Glatzel, Nick Reid, Mark Smith, Jake Overton, Bob Mathiasen, Del Wiens, and Bryan Barlow. The conference organizers are accepting contributed papers and with enough contributions a session on mistletoes and other forest diseases of the canopy could be in the making.

Associated with this meeting, is a proposed international workshop: **Developing a global mistletoe research framework**. Catherine Parks and David Shaw are writing a NSF proposal to fund U.S. scientist travel to the workshop. We hope to include other international members of the scientific community, and get a group of about 25 to 30 individuals together. The purpose of the workshop is to determine whether interest exists in developing an integrated mistletoe research framework for understanding ecology, biology and evolution of mistletoes. Although many books and synthesis works on mistletoe ecology have been written, still relevant questions may include; "What are the existing needs in mistletoe research? What are the major gaps in our knowledge of mistletoes? Is THE emerging issue in applied ecology the relationship of mistletoes and biodiversity of forest canopies? " (D. Shaw, Wind River Canopy Crane Research Facility, University of Washington).

b) Project title: *Biological Control Approach for Management of Dwarf Mistletoes*
Research Objectives: The overall objective of the project is to survey and collect fungal hyperparasites and to investigate their potential use as biological control agents for dwarf mistletoes. Currently the focus of this research program is on biological control of western hemlock and lodgepole pine dwarf mistletoes. Most recently, research efforts are underway to explore the use of genetic control method for management of western hemlock dwarf mistletoe.

Research progress: Tissue culture of western hemlock dwarf mistletoe (*Arceuthobium tsugense* subsp. *tsugense*) – a novel procedure for *in vitro* culture of western hemlock dwarf mistletoe was developed for the first time. The tissue culture procedure will be useful for studying genetic

resistance and the physiological and biochemical mechanisms of the host-parasite interactions, as well as, to screen naturally occurring hyperparasitic fungi for their potential use as biological control agents against dwarf mistletoes. A full manuscript was published in Plant Cell, Tissue and Organ Culture 2001, Volume 66 (2): 97-105.

Histopathological investigation of the infection of germinated seeds and callus of western hemlock dwarf mistletoe by *Nectria neomacrospora* (Anamorph: *Cylindrocarpon cylindroides*) and Colleto*trichum gloeosporioides* in dual culture- the selection of these two hyperparasitic candidate fungi was based on their performance as promising biological control agents under field conditions. The potential use of these two fungi was evaluated for their pathogenicity on germinated seeds and callus grown *in vitro*. A full manuscript was submitted to the International Journal of Plant Sciences.

Field trials- continue monitoring of the field trials which were initiated in 1997 on the potential use of *Cylindrocarpon cylindroides* and *Colletotrichum gloeosporioides* as potential biological control of western hemlock dwarf mistletoe.

Exploring the use of genetic resistance strategy for management of western hemlock dwarf mistletoe- early results suggests levels of resistance to western hemlock dwarf mistletoe within western hemlock clones in conifer plantations in British Columbia. An understanding of the mechanisms involved and factors influencing resistance to western hemlock dwarf mistletoe will support the selection and breeding the host plants which are more resistant to infection. Research objectives include: 1) utilization of *in vitro* (tissue culture) system already developed at Dr. Shamoun's lab. as a rapid screening method for resistance in western hemlock populations to western hemlock dwarf mistletoe; 2) elucidation and characterization of inheritance of resistance in hemlock populations to western hemlock dwarf mistletoe. To date, we have inoculated 300 young seedlings of western hemlock representing 50 provenance under greenhouse conditions. This ongoing experiment will be monitored in the next 1-3 years for selection different resistance traits to western hemlock dwarf mistletoe. This research venture is a collaborative research effort with Charlie Cartwright- Hemlock Breeder, BC Ministry of Forests, Victoria, BC.
Biological control of lodgepole pine dwarf mistletoe- this project is part of a Ph.D. work conducted by Tod Ramsfield (Ph.D candidate at UBC- Dept. of Forest Sciences) who is working under the direction of Drs. Bart van der Kamp and Simon F. Shamoun. Overall objectives of Mr. Ramsfield's Ph.D work includes: 1) feasibility of potential use of *Colletotrichum gloeosporioides* as a biocontrol agent for lodgepole pine dwarf mistletoe under field conditions (to date, two years data has been collected. Results of this experiment will be presented as a poster at the WIFDWC meeting in Carmel, California, September 10-14, 2001. 2) effect of shoot removal on dwarf mistletoe (i.e., how lodgepole pine dwarf mistletoe responds to stress). 3) modeling dwarf mistletoe seed production. 4) *Caliciopsis arceuthobii*- description of the effects of this fungal parasite and it's impact on lodgepole pine dwarf mistletoe. 4) occurrence of *C gloeosporioides* and its frequency at different canopy level of the infected lodgepole pine with dwarf mistletoe. 5) Histopathological investigation- to determine if *C. gloeosporioides* penetrate the endophytic system of the lodgepole pine dwarf mistletoe. In addition molecular markers, including PCR-DNA/ ELISA tools be utilized to detect any evidence of *C. gloeosporioides* in the endophytic system.

Most recently, Forest Renewal BC (FRBC) has awarded a research grant to Drs. Simon Shamoun and Bart van der Kamp to continue their investigations on "Development of Biological Control Agents for Management of Western Hemlock and Lodgepole Pine Dwarf Mistletoes". As a result, two new graduate students at M.Sc. level, Lea Riteman and Sue Askew, as well as, a Research Technician Anna Mary Schmidt have joined this research program.

An I.U.F.R.O. working party has been established "Parasitic Flowering Plants in Forests". Dr. Simon Francis Shamoun has been selected as a Coordinator for this group. This working party is planning to have future international meetings in 2003 (proposed site-Poland) and in 2005 in Brisbane, Australia. For more information, please, contact Dr. Simon Shamoun, by e-mail: sshamoun@pfc.forestry.ca, phone: (250)363-0766, or fax: (250)363-0775. (Dr. Simon Francis Shamoun- Research Plant Pathologist & Adjunct Professor, Canadian Forest Service, Pacific Forestry Centre, and University of British Columbia- Dept. of Forest Sciences, Vancouver, BC & University of Victoria- Dept. of Biology, Victoria, BC).

c) The Mistletoe Literature Database is an annotated bibliography of journal articles and various published reports on the biology, ecology, management, and uses of mistletoe. Dan Huebner has recently upgraded the search capabilities of the database, and we continue to add new papers as they become available (if you want your paper listed, send a copy to B. Geils). We are continuing to add images, links, and text pages to the resident site, the Mistletoe Center (online at http://www.rms.nau.edu/mistletoe). (B. Geils and D. Huebner, Rocky Mountain Research Station, Flagstaff, AZ).

XII. COMMITTEE MEETING NOTES

24 people attended the committee breakfast on September 11th. The Chair suggested that notes from the meeting be added to the committee report, including a sentence or two describing items mentioned during the Round Robin that were not submitted prior to the meeting. The group agreed with this suggestion.

Revisions of Forest Insect and Disease Leaflets (FIDLs) are in progress for pinyon pine dwarf mistletoe, gray pine dwarf mistletoe and sugar pine dwarf mistletoe. They will be completed and printed in 2002. Layout was done by the Washington Office. Region Five provided the funds for printing 3000 copies of each FIDL. They will also be available as .pdf files on the Internet. J. Pronos hopes to finish the western dwarf mistletoe FIDL soon which would round out the FIDLs that needed revision. According to J. Beatty, the Washington Office is willing to do layout of FIDLs in the future.

The group discussed whether dwarf mistletoes are still a concern for forest managers, given the recent changes in management direction. A number of people expressed the importance of continuing research, particularly about wildlife/dwarf mistletoe interactions and fire effects, issues that are controversial under current management and about which there is little hard data. The importance of conducting research at the landscape level and providing good documentation was also discussed.

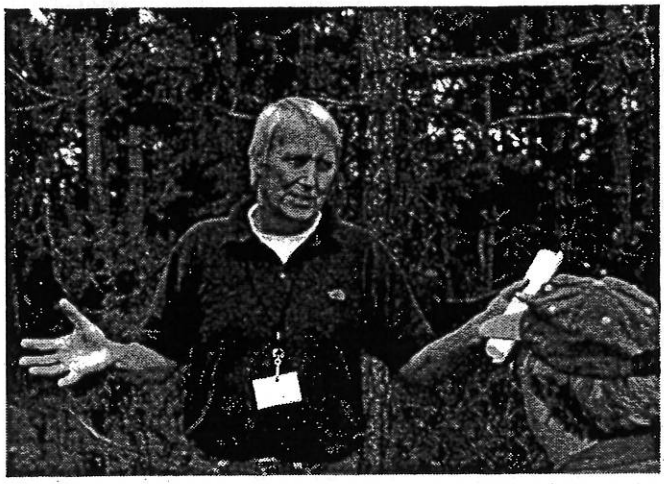
It was pointed out that last year dwarf mistletoe-related projects were low on the list for Suppression funding. According to the Washington Office (J. Beatty) the onus is on the Regions to set their own priorities. However, the Washington Office does categorize funds based on national priorities before they are allocated to the Regions.

T. Ramsfield: In his second season inoculating lodgepole pine dwarf mistletoe in the field with *C. gloeosporoides*. It was hard to see the fungus but it seems to have reduced the fruiting of the dwarf mistletoe (see VIII. Management).

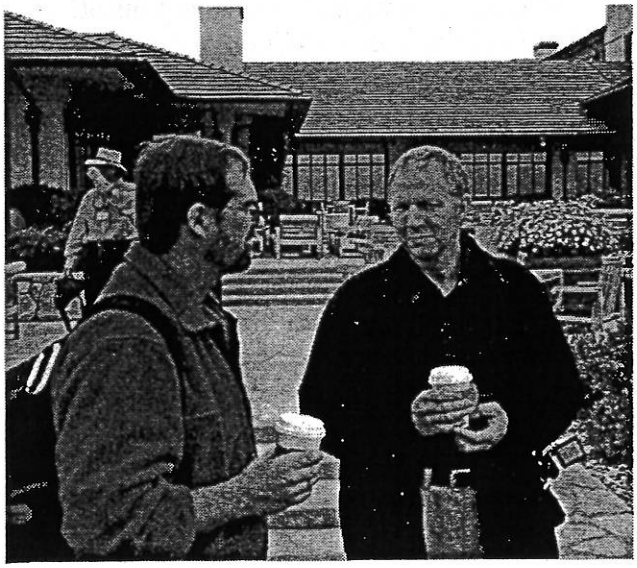
D. Shaw: Initiating a project to look at the effect of dwarf mistletoe on tree hydraulic architecture using the Wind River Canopy Crane. This season a sap flow measuring system was installed in 170 to 180 feet tall trees. Also initiating a project on the mistletoe hairstreak butterfly, an

herbivore on dwarf mistletoes.

J. Muir: Has research on small block harvesting and impact on hemlock dwarf mistletoe and its effect on the trees. Also working on dwarf mistletoe simulator of FVS for British Columbia Coast and hemlock dwarf mistletoe, especially spatial relationships of dwarf mistletoe infection in mature trees.



Det Vogler



Greg Filip and Eric Allen

Hazard Tree Committee Report

Submitted by John Pronos

The Hazard Tree Committee sponsored its third Western Hazard Tree Workshop in Coeur d'Alene, Idaho, from May 22-24, 2001. About 60 people attended, and 19 different speakers made either individual presentations or participated in one of 6 panels. Panel topics included: Effects of Wind On Trees; Snag Biology; Legal Issues; Data Collection and Management; Hazard Tree Case Studies; and Concessionaires and Hazard Trees. One-half of the 3-day workshop was spent on indoor discussions and the other half was spent in the field. John Schwandt and Jane Taylor organized the field trips and made local arrangements. Panel organizers included Alan Kanaskie, Jim Hadfield, John Guyon, Pete Angwin, Mary Lou Fairweather and Jim Worrall.

The previous workshops were held on a cycle of three years, and if this remains the pattern, the next workshop will be in 2004.

The Hazard Tree Committee had its annual meeting during lunch on September 11, 2001 at the Carmel, California WIFDWC. Thirty-four people attended and discussed the following 3 topics:

1. A summary/review of the HT Workshop in Coeur d'Alene. Copies of the agenda, attendee list and presentation summaries were available. If we meet in 2004, two possible locations are Region 2 or Region 3.

2. Using measured stress to test defective trees. One presentation at the Coeur d'Alene workshop described how measured stresses generated by a winch and cable were used to determine how much wind force healthy trees could withstand. We discussed the possibility of using this technique to test defective trees.

3. National tree failure database. The Forest Health Technology Enterprise Team in Fort Collins has agreed to maintain a database and website for tree failures in the U.S. and Canada (FHTET contact is Judy Adams). This national program will be modeled after the California Tree Failure Reporting Program that has been operating since 1990. People who have volunteered to help guide this effort include: Joe O'Brien, Jim Worrall, John Muir, John Schwandt and John Pronos.

Root Disease Committee Report

Submitted by Ellen Michaels Goheen

The Root Disease Committee met for breakfast on Thursday, September 13, 2001.

Brennan Ferguson gave a short presentation on work he is doing that describes the genet structure of *Armillaria ostoyae* on two mixed conifer landscapes: one in northeastern Oregon and one in northwestern Montana. Objectives of the study were to determine the species of Armillaria causing mortality and assess genet size and diversity. Collections were made from live trees symptomatic for root disease and recently killed trees. Somatic incompatibility pairings were used to determine species and genet.

Results: The Armillaria collection from Montana consisted of approximately 75 isolates, all *A. ostoyae*. Pairings revealed the presence of 52 genets across the studied landscape; the largest of these was approximately 100 ha in area. Most genets were represented by one to two samples collected from either small groups of trees or individual trees with root disease symptoms.

The Armillaria collection from Oregon consists of 112 isolates; 106 *A. ostoyae* and 4 NABS-X. The *A. ostoyae* isolates represented 5 genets, the largest of which is approximately 1135 ha. All four NABS-X isolates came from one genet. No *A. ostoyae* genets overlapped or were found within the boundaries of another genet.

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Blakey Lockman gave a presentation on evaluations of ponderosa pine mortality and symptom expression on the Flathead Indian Reservation in northwestern Montana. Needle loss and lion's tails were observed on overstory ponderosa pine in the late 1980s and early 1990s. A cumulative symptom rating system for trees was used to evaluate individual trees. Annosum root disease was associated with some dieback and symptom expression.

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The bulk of the rest of the meeting was spent discussing the committee's proposal to sponsor a panel at the 2002 WIFDWC on root diseases and fertilization treatments. Brennan Ferguson and John Schwandt agreed to organize a panel specific to that subject and also to organize a panel or discussion section on tree physiology/tree response as relates to nutrient status. Potential subjects/areas to include in these panels might be:1) a review of the subjects, 2) different fertilizers proposed as root disease treatments, 3) different root diseases, 4) thinning by fertilization interactions, 5) mycorrizhal interactions, and. 6) recent information on plant defense mechanisms.

The last 10 minutes of committee time were spent in a quick round robin of projects and studies.

Rust Committee Report

Submitted by Brian Geils

The Rust Committee Lunch (September 13, 2001) was attended by 15 people. We heard brief reports that generated some discussion.

Brian Geils reported on several scouting trips to assess blister rust potential hazard in southeastern Arizona and southern Colorado. John Muir provided a review of the Corvallis blister rust-*Ribes* meeting and described a situation that may illustrate age-dependent resistance in a western gall rust pathosystem. Det Vogler related some of his observations of western gall rust that do not show evidence of age-dependent resistance; he also asked for samples of *Ribes* leaves with rust to build a genetic library. Paul Zambino outlined his future studies on *Ribes*-rust genetic interactions, inoculating detached candles, distinguishing MGR from non-MGR trees, and screening for slow rust reaction. Richard Sniezko reported on segregation of rust populations and on work by George Newcomb dealing with protection from endophytes. Eric Smith described an exercise to determine the distribution of limber pine in Colorado, spatial relation to *Ribes* and implications for future development of blister rust outbreaks. Bill Jacobi discussed the difficulty of estimating how long blister rust had been present on some limber pine sites in Wyoming and Colorado.

Disease Control Committee Report

Submitted by Robert L. James

The Disease Control Committee met on September 14, 2001. Only 6 people were in attendance. We primarily discussed the need for and future of the committee. During the past several years there has been very little interest in the committee; most of the discussions have concerned applications of direct disease control involving forest nurseries. There has been little, if any, input from other WIFDWC subject areas such as dwarf mistletoes, root diseases, rust diseases and tree hazards. Much of the discussions in the Disease Control Committee have been continuations of those initiated during the nursery pathology meeting associated with WIFDWC.

The consensus of this year's discussions was that the Disease Control Committee should be dissolved. The other four WIFDWC committees should include topics dealing with disease control in their discussions. Disease control applications in forest nurseries will be included in the nursery pathology meeting attached to WIFDWC. A summary of that meeting will be included in the WIFDWC proceedings each year.

If the WIFDWC membership believes it is necessary to form an "invasive species" committee, the topic should be discussed in a forthcoming business meeting. Currently, it is not felt that the Disease Control Committee should be redesigned to include discussions of issues concerning invasive species.

A proposal to dissolve the Disease Control Committee will be made during the next WIFDWC business meeting. Topics normally included in the Disease Control Committee meetings will be covered by the other WIFDWC committees and the nursery pathology meeting.

BUSINESS MEETING MINUTES

Submitted by Katy Marshall

Chairman Dave Johnson called the meeting to order at 3:30 pm on Thursday, September 13, 2001.

Thanks were extended to the WIFDWC 2001 Executive Committee: Susan Frankel, Local Arrangements; Alan Kanaskie, Program, Katy Marshall, Secretary; John Schwandt, Treasurer and Judy Adams, Webmaster.

71 people registered for WIFDWC this year. There were also 10 attendees from the North American Forestry Commission, Insect and Disease Study Group. There were 97 people on the field trip, including some spouses who attended.

The minutes of the 2000 WIFDWC business meeting in Kailua-Kona, Hawaii were approved as written.

Committee Reports

Dwarf Mistletoe Committee: Katy Marshall reported that 24 people attended the meeting. The group discussed the future of the dwarf mistletoe program, future research and funding. Details of these discussions and reports on participant's current projects will be described in detail in the committee report in the Proceedings.

Hazard Tree Committee: John Pronos reported that 34 people attended the committee meeting. In May 2001 the committee sponsored a workshop in Coeur d'Alene, Idaho that was attended by 50 people. The agenda and a collection of speaker's summaries are available from John upon request. The Southern chapter of the Society of Arboriculture will have a tree mechanics workshop in Savannah, Georgia in October 2001. An Oregon State University graduate student will attend. The Forest Health Technology Enterprise Team located in Ft. Collins will maintain the Tree Failure database if people will contribute to it. The Hazard tree committee is considering a standing committee to take care of this.

Root Disease Committee: Ellen Goheen reported that 20-something people attended the meeting. Brennan Ferguson presented information about *Armillaria* genets in Idaho versus northeastern Oregon and Blakey Lockman discussed monitoring of ponderosa pine on the Flathead Reservation in Montana. The committee is planning a panel at WIFDWC 2002 on fertilization and tree nutrition relationships to root disease.

Rust Committee: The committee met but did not make a report at the business meeting.

Disease Control Committee: Bob James announced that the committee would meet informally over breakfast on Friday to discuss its future.

Future Meetings

The Railroad Committee announced nominees for officers for WIFDWC 2002: Chairman, Bart van der Kamp; Program, Paul Hennon; Secretary, Brian Geils. These selections were approved,

seconded and passed. John Schwandt will continue as Treasurer and Judy Adams will continue to administer the WIFDWC website.

WIFDWC 2002 will be held in Powell River, British Columbia. It will be the 50th anniversary meeting. Stefan Zeglen is in charge of Local Arrangements. Powell River is about 90 miles northwest of Vancouver, B.C. on the mainland along the Strait of Georgia. Access is via airplane from Vancouver or by car and two ferries. Potential dates for the meeting were discussed and September 9-13, 2002 was proposed because would avoid the heavy tourist season. The general consensus was that the Executive Committee should try to schedule the meeting early (August) since it is an "early meeting year" but recognized that it will be up to them to make the final decision. The option of having the meeting over a weekend was proposed. A vote was taken and the proposal was unanimously rejected.

WIFDWC 2003 will be held in southern Oregon. It should be a September meeting. Ellen Goheen will be in charge of Local Arrangements. Potential locations for the meeting were discussed. Ashland, Grants Pass and Diamond Lake Resort were proposed. A vote was taken on locations and there was strong support for holding the meeting in a remote location such as Diamond Lake.

In 2004 WIFDWC will be a joint meeting with the Western Forest Insect Work Conference (WFIWC). It will probably be in the Spring with the location to be selected by the entomologists. Everett Hansen was nominated as Interim Program Chair to work with the entomologists on a joint program. His nomination was approved, seconded and passed. A suggestion was made to try and have integrated sessions.

Old Business

The WIFDWC Outstanding Achievement Award will be presented at the banquet. Greg Filip was nominated to replace Will Littke on the Award committee. The nomination was approved, seconded and passed. The award committee for 2002 will be Bart Van der Kamp, Rona Sturrock and Greg Filip.

In 1999 Fred Baker volunteered to investigate publishing the WIFDWC Proceedings on CD-ROM. The issue was tabled until next year since Fred was not present.

In 2000 there was a proposal to change the name of the Disease Control Committee but the subject was tabled for further discussion. Bob James announced that the committee would discuss the matter at its Friday meeting and put a report in the Proceedings with recommendations to discuss in 2002.

John Schwandt is continuing to investigate getting WIFDWC officially designated by the IRS as a 501(c)(3) tax-exempt educational organization. We currently meet the requirements of a tax-exempt organization, but our level of financial activity does not require us to apply for official designation. However, if we foresee greater financial activity or plan to create endowment funds for scholarships or awards, it might make it easier to solicit donations. The only restriction is on the amount of political lobbying that WIFDWC could do. It would cost $150 to file for the official designation and we would have to include financial statements and a "conformed copy" of our organizing instrument (our by-laws might work).

New Business

Susan Frankel recommended that WIFDWC register a domain name (e.g. wifdwc.org) and have a WIFDWC website. Bylaws, forest pathology information and links to other organizations and sites could be posted. The cost would probably be about $75 for 2 years. Someone must maintain the site. The group discussed whether it would be better to have our own website or continue to use the Forest Service website with more and better links added. It was agreed that Dave Shaw and Jerry Beatty will discuss improving access to our current website with Judy Adams and take action and/or report next year.

Stefan Zeglen suggested that WIFDWC appoint an Archivist to collect information that would be of interest for the 50th anniversary meeting next year. During the ensuing discussion it was pointed out that Duncan Morrison is already the official WIFDWC Historian and that John Muir has information about who was at the first meeting. It was suggested that their work be highlighted in the Program. The group decided that the Program Chair, Paul Hennon, should consider suggestions. Ideas included sending special letters to Honorary Life Members (HLMs), inviting 1 or 2 HLMs to speak and possibly offering financial incentives.

Jerry Beatty suggested that WIFDWC consider joint meetings with other regional pathology working groups such as the North Central, Northeastern and Southern Working Groups. It was moved that Jerry Beatty attend the Southern meeting, propose the idea of a joint meeting to them and report back to WIFDWC next year. The motion was approved, seconded and passed.

Everett Hansen suggested that WIFDWC write a letter to universities soon suggesting that they take action to encourage the future of their forest pathology programs. There are pressing issues in western forests; yet many professors are retiring and few new graduate students are appearing. There was a discussion of the issue but no decision was made.

The meeting was adjourned at about 5 pm.

Walt Thies, Joe O'Brien and Gail Thies

TREASURER'S REPORT

Submitted by John Schwandt

We had 71 people register for this years meeting (including 8 students and 2 retirees). In addition, 10 members of the North American Forestry Commission I&D study group joined us for parts of the meeting. There were 97 people on the field trip (including a few spouses). The following is a summary of transactions for the WIFDWC account since 12/31/2000, and includes transactions related to the 2001 Hazard Tree Workshop in Coeur d'Alene, Idaho, May 22-24, 2001.

TRANSACTION	INCOME	EXPENSES	BALANCE
Balance reported in last report (as of 12/31/00):			150.82
2000 WIFDWC - meeting Waikoloa, Hawaii			
Printing/binding/mailing of Proceedings		pending	
2001 WIFDWC meeting –Carmel, California			
Total registration	8,950.00		9,100.82
Committee Meetings, Banquet, Field trip	7,168.00		16,268.82
Meeting setup expenses		325.40	15,943.42
Hotel meeting rooms, breaks, meals, etc.		4,953.98	10,989.44
Audiovisual Equipment		1,398.30	9,591.14
Field trip transportation		1,680.00	7,911.14
Field trip food and entrance fees		125.89	7,785.25
Outside speaker expenses		500.00	7,285.25
Bank Interest/dividends/service charges	49.58	6.00	7,328.83
Printing/binding/mailing of Proceedings		pending	
WIFDWC Balance as of 10/31/2001			7,328.83
HAZARD TREE WORKSHOP – Coeur d'Alene , ID 5/22-24/2001			
Prior Balance – last report (as of 12/31/00)			2,217.13
Total registration	4,730.00		
Meeting setup expenses, breaks		235.72	
Field trip transportation		490.00	
Field trip food and entrance fees		670.98	
Outside speaker expenses		2,550.89	
Hazard Tree Balance as of 10/31/2001 ($782.41 surplus)			2,999.54
Total Bank Balance as of 10/31/2001			10,328.37

OUTSTANDING ACHIEVEMENT AWARD

Based on a vote at the Business meeting, October 2, 1998

Purpose: Recognize outstanding achievement in the field of forest pathology in Western North America. The award will recognize the individual that has contributed the most to the field of forest pathology in Western North America.

Award: The award winner will be announced at the banquet. The awardee will present a keynote address at the following year's WIFDWC. A list of winners will be printed in the Proceedings. The winner will receive a framed certificate and some sort of gift to be determined by the award committee. They will also become keeper of the social achievement award hat, tie, etc for one year or until the award is given again.

Selection Process: The award will be given annually. An award committee composed of three WIFDWC members will determine the awardee. The award committee will be selected annually by the WIFDWC executive committee *(at the business meeting on August 16, 2000; members decided that award committee members will serve three year terms, with one new member joining and one old member leaving the committee each year. The new member will be elected at the business meeting each year).* The committee will be comprised of a representative from each of the following: a university researcher, a public agency employee, and one member-at-large. One member should be working in Canada.

Nomination Procedures: WIFDWC members may nominate another member for the award, they may not nominate themselves. An individual may only nominate one person per year.

There is no formal nomination form but the following guidelines are provided (printed in the Proceedings, included in a WIFDWC mailing, and available on request from the chairman of the award committee).

- Short introduction letter
- Narrative of nominees qualifications, educational background, work history, etc.
- Letters of support from other individuals and organiations
- Copies of a few of the nominee's publications

Nominations are due three months prior to the starting date of the next year's conference and should be sent to the chairman of the award committee.

The award committee may decide not to name a recipient if suitable candidates are not nominated.

OUTSTANDING ACHIEVEMENT AWARD WINNERS

Year	Winner	Location	Comments
1999	No award given		
2000	Lew Roth	Kailua-Kona, HI	For pioneering work on *Phytophthora lateralis*, *Armillaria* and dwarf mistletoes, and for inspiration and leadership of a generation of plant pathology students and colleagues
2000	Duncan Morrison	Kailua-Kona, HI	For long-standing contributions to forest pathology research, especially in relation to root diseases and tree hazards
2001	Bob Gilbertson	Carmel, CA	For contributions to the taxonomy and identification of wood-inhabiting basidiomycete fungi

WIFDWC 2001

DEPARTMENT OF BOTANY AND PLANT PATHOLOGY

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January 18, 2001

Dear W.I.F.D.W.C. Colleagues:

Thank you for the very handsome plaque received in recognition of past contributions to improved forest health. I'm not sure that the recognition is deserved.

In retrospect I do find some satisfaction in that something useful to forest management has resulted from our research on each of the numerous diseases we investigated.

I use the term we, of course, because these results could never have been achieved without the dedicated work of many graduate students and particularly without the support and help of my beloved wife Evelyn (Lyn).

One of the greatest joys across retirement years have been visits from former students both graduate and undergraduate. These relationships are a real reward for teaching.

Thank you for your thoughtfulness.

Sincerely,

Lew

Lew Roth
Emeritus Faculty

RELATIONSHIP OF ENVIRONMENTAL STRESS AND CYTOSPORA CANKER OF ASPEN

W.R. JACOBI, G.A. McINTYRE, S. BURKS, J.C. GUYON, and A.W. RAMALEY

Department of Plant Pathology and Weed Science, Colorado State University, Fort Collins, Colorado USA

POSTER SUMMARY

Cytospora canker (Cytospora chrysosperma (Pers.) Fries) is one of the most important diseases of urban and forest grown aspen (Populus tremuloides Michx.) in Colorado. Canker incidence is suspected to be related to predisposing environmental stresses. Our research is aimed at determining these stresses and the degree of stress needed to increase susceptibility of aspen.

The research was completed over the last 6 years in nursery and greenhouse experiments. One to 5-year-old aspen seedlings were used in greenhouse studies and 10 to 12-year-old trees in nurseries. The following stresses were assessed as to their effect on canker initiation and expansion: drought, flooding of roots, defoliation, and nitrogen deficiencies and excesses. Pressure bombs were used to measure tree water potentials during drought studies. Drought was induced 7 days before inoculation by withholding water until tree water potentials reached 1.5 to 2.0 MPa. Then a small amount of water was added to prevent death. Thus, a cyclic drought stress was applied. Flooding was simulated by putting potted aspen in tanks of water 2 days before inoculation. Trees were defoliated at levels of 0, 50, 75 and 100% by removal of leaves for 4 weeks before inoculation. Nitrogen was applied to greenhouse trees at 0, 66, 185, and 360 ppm 6 weeks before inoculation. Trees were treated with these nitrogen concentrations a second year. All experiments utilized at least two C. chrysosperma isolates and were repeated at least twice. Canker size (length and width) was recorded weekly for 4 to 6 weeks after inoculation.

Drought affected host/pathogen relationships in various ways. In the spring, the duration wounds remained susceptible to infection increased from 2 or 4 days on watered trees to at least 10 days on drought stressed trees. Resistance, based on the number of successful infections, started on watered trees two days after wounding and after 6 to 8 days on drought stressed trees. In greenhouse studies, trees under drought stress had significantly ($P=0.5$) larger cankers than non-stressed trees. The number of successful infections on field grown aspen increased from 16 to 100% as water potentials increased from 0.7 to 2.0 MPa during the growing season. Increased water potential at or above 1.0 MPa using polyethylene glycol in the growing medium induced a significant growth decrease in the pathogen. Thus, fungal growth is not favored by low water protentials in the host but by reduced host resistance.

Flooding of root systems did not affect aspen water potential or size of cankers, but did cause partial defoliation after 3-6 weeks. Trees with defoliation amounts of 75 and 100% had significantly larger cankers than non defoliated trees. Aspens receiving no nitrogen had significantly larger cankers after one and two growing seasons.