Proceedings of the 56th Annual Western International Forest Disease Work Conference

October 27-31, 2008
Missoula, Montana

St. Mary's Lake, Glacier National Park

Compiled by: Fred Baker
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Holiday Inn Missoula Downtown At The Park

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PROGRAM

MONDAY, OCTOBER 27TH

1:00 - 5:00 pm	Nursery Pathology Committee Meeting (Katy Mallams)
4:00 - 8:00 pm	Registration
7:00 - 10:00 pm	Welcome Social
All Day	Pre-WIFDWC Field Trip

TUESDAY, OCTOBER 28TH

7:00 - 8:30 am	Foliage/Twig Disease Committee Breakfast (Harry Kope)
8:00 am - 5:00 pm	Registration
8:30 - 8:45 am	Welcome from WIFDWC Chair Gregg DeNitto
8:45 - 9:00 am	Introductions
9:00 - 9:30 am	Keynote Address (Bob Harrington, State Forester, MT)
9:30 - 10:00 am	Distinguished Achievement Award Recipient (Rich Hunt)
10:00 - 10:30 am	Break
10:30 - 12:00 am	Student Session (Michelle Cleary, moderator)
12:00 - 1:30 pm	Root Disease Committee Lunch **(**Brennan Ferguson)
1:30 - 5:00 pm	Panel: **Climate Change: Focus on Carbon for Forest Pathologists** (Susan Frankel, moderator) **Impacts of Climate Change for Drought and Wildfire** (Faith Ann Heinsch, University of Montana) **Carbon offsets in the forestry sector: What is being done to manage carbon? What can be done?** (Keegan Eisenstadt, CEO, ClearSky Climate Solutions, Missoula, MT)
3:15 pm	Break **Mountain Pine Beetle and Eastern Spruce Budworm Impacts on Forest Carbon Dynamics** (Caren Dymond, BC Ministry of Forests, Victoria) **Climate Change's Influence on Decay Rates** (Robert Edmonds, Univ. of Washington)
4:30 pm	Discusion
5:00 – 6:00 pm	Climate Change Meeting (Susan Frankel)
7:00 – 9:00 pm	Ice Cream Social/Poster Session (Amy Ramsey, poster session moderator)

WEDNESDAY, OCTOBER 29TH

7:00 – 8:20 am	Hazard Tree Committee Breakfast (Pete Angwin)
8:30 am – 5:00 pm	Field Trip (Full Day) - Exploring the Beautiful Bitterroot We will be spending Wednesday traveling up the BitteFrroot Valley south of Missoula 1) Bass Creek: Charles Waters Campground and Larry Creek Group Site 2) Vegetation Mgmt Plans: MPB, annosus root disease, elytroderma 3) Aspen: R1 survey and westwide comparison 4) Lunch! 5) S. Fork Lolo Creek: Oscar Dooling's DFDM plots- est. in 1970 6) Bear Creek: Root Disease Permanent plots- est. in 1990
5:00-6:00 pm	Business Meeting

THURSDAY, OCTOBER 30TH

7:00-8:30 am	Rust Committee Breakfast Meeting (Holly Kearns, moderator)
8:30-10:30 am	**Invasive Species: Learning By Example** (Ellen Goheen, moderator) **Is Firewood Moving Tree Pests?** (William Jacobi, Department of Bioagricultural Sciences and Pest Management, Colorado State University) ***Phytophthora alni* in Alaska: Lessons Learned** (Lori Trummer, USDA Forest Service, Forest Health Protection, Anchorage, Alaska and Gerry Adams, Department of Plant Pathology, Michigan State University)

THURSDAY, OCTOBER 30TH

8:30-10:30 am

If We Knew Then What We Know Now: *Raffaelea lauricola*, the Cause of Laurel Wilt in the Southeastern US (Bruce Moltzan, Forest Health Protection, Wash. DC)

Application of GIS Models as a Decision Tool for Continued Eradication of Citrus Canker Epidemics in an Agro-urban Landscape (Tim Gottwald, Horticultural Research Laboratory, Fort Pierce, Florida)

11:00-5:00 pm

Field Trip (Half-day) - Whitebark Pine: A Tree in Peril?
We will be spending Thursday afternoon traveling up to Montana Snowbowl for lunch, Followed by a field trip in whitebark pine forests. Highlights tentatively include:

1) mountain pine beetle infestation
2) whitebark pine restoration
3) white pine blister rust in whitebark pine

6:00-10:00 pm

Banquet: **"Ice Age Floods"** Presentation by Jim Shelden, USFS Regional Geologist

FRIDAY, OCTOBER 31ST

7:00-8:30 am

Dwarf Mistletoe Committee Breakfast **(**Greg Filip)

8:30-10:00 am

Special Papers (Bob Edmonds, moderator)

Twenty-five Year History of Lodgepole Pine Dwarf Mistletoe (*Arceuthobium americanum*), Animal Vectors, and Ethephon Control on the Fraser Experimental Forest, CO (Thomas H. Nicholls)

Comparison of Two Dwarf Mistletoe Rating Systems for Infected Douglas-fir (Katy M. Mallams)

Inoculation of Whitebark Pine Seedlings with Native Mycorrhizal Fungi: Preliminary Screening Results (C. L. Cripps)

Survey of *Seiridium* Species Associated with Cypress Canker in Oregon (Danielle Martin)

Survey of *Armillaria* spp. in the Oregon East Cascades: Baseline Data for Predicting Climatic Influences on Armillaria Root Disease (J.W. Hanna, A.L. Smith, H.M. Maffei, M.S. Kim and N.B. Klopfenstein)

Wood Decay Fungi Associated with Beetle-Killed Lutz Spruce (*Picea* x *lutzii*) from the Kenai Peninsula, AK: Culture Studies (J.A. Glaeser, D.L. Lindner, M.T. Banik and L Trummer)

Forest and Shade Tree Disease Studies-Fall 2008 Colorado State University (B. Jacobi, Meg Dudley, Anne Marie Casper and Dan West)

Crown Distribution of Disease Symptoms in Douglas-fir Infected with Swiss Needle Cast Across a Gradient of Infection Levels in the Oregon Coast Range (Dave Shaw and Travis Woolley)

The Effect of Site and Silvicultural Treatment on Insect Pests and Diseases of Young Ponderosa Pine (Danny Norlander and David Shaw)

Influence of Nursery and Stock-type on Incidence of White Pine Blister Rust (Stefan Zeglen)

Screening Interior Douglas-fir for Genetic Resistance to *Armillaria ostoyae* (Mike Cruickshank and Barry Jaquish)

Cronartium comandrae*: Investigating Host Resistance, Alternate Host Susceptibility, and the Proximity Relationship for *Geocaulon lividum (Richard Reich)

Native Ectomycorrhizal Fungi and Whitebark Pine (Cathy Cripps and P.Trusty)

Opening Remarks
WIFDWC Chair Gregg DeNitto

Welcome to the 56th annual meeting of the Western International Forest Disease Work Conference. As many of you know, the Missoula area is known as fishing mecca. It was immortalized in Norman McLean's book "A River Runs Through It". Well, this WIFDWC is the one that almost got away. Although we had it hooked, starting in August it started jumping and twisting, trying to get rid of our hook. Finally, in early September we were able to get the hook set deep, although it has given us quite a fight since then. It's only through the willingness of people to help us out and change their plans, and to the indomitable determination of the planning team and local arrangements, that we are we close to landing this beauty. My thanks to all of you for your help in making sure our string of WIFDWC's did not have a break. Once we made the change in date, we knew there would be challenges ahead. Little did we know what they were and how they would come about.

Our first concern was for the weather. Late October is reliably uncertain and snow is certainly a possibility, even on the valley floor. Taking all of you on 2 field trips, one up to 7500 feet had us worried. But then we found out some other concerns as this fish kept thrashing. This past Sunday was opening day of general big game hunting in Montana. Surprisingly, a number of the people who work in the woods around here and who we were planning on helping us decided they had a higher priority than us. Go figure. But we kept letting out some slack and reeling in, finding some other souls just as capable who are giving us a hand. Also because of hunting season, a number of roads to areas we wanted to visit have been closed to give the hunters more solitude. But we're trying to land a fish, so we had to find new locations to take you, and we've found as good, or maybe better, locations. Of course, we should have expected the unexpected—that old fish just didn't want to get landed. Our planned first stop on Wednesday's trip became the dumping grounds for a methamphetamine lab just a few weeks ago. Needless to say, by now we were getting pretty darn tired, but our field trip crew persevered and have found a work around. So at this point we think we have the net around this critter and ready to bring it on board—and what a beauty it is. You'll have a great time admiring this meeting and everything you are about to hear and see. But I'll remind you, we do catch and release, so come Friday we'll let go and let the Coloradans have a hand at trying to land a big one.

I'd like to remind everyone why we are together this week. It's to share—knowledge, information, experience, even stories—both formally in presentations and posters and informally during breaks, dinner, even over a beer. Take the time to share what you know and learn from others. This is especially true for those of you who are newer to our profession and organization. There are some pretty great brains out there that you need to pick. We are doing things a bit different this year and asking all students to give us a few minutes of their time and tell us about themselves and what they are working on or think they might want to work on. We aren't asking for fancy presentations, just give us a flavor and if you don't know yet, that's fine. Tell us about yourself—give us a chance to know you. And you more senior members of our group—introduce yourselves to all of these students and young professionals. Remember back to your first few meetings and what impressions you still have of those who you met. Provide yourself a legacy by sharing your knowledge with our successors as our predecessors did with us.

WIFDWC is not a meeting. It is a gathering of experience that needs to be shared amongst all of its members. So, let's have a great meeting—no matter how much that fish jumps and thrashes—and regardless of how conditions turn out, let's keep up the traditions of WIFDWC and pass them on to our future.

Special Thanks to Bill Jacobi for the great selection of photos!!!

Panel: Climate Change and Forest Pathology – Focus on Carbon

Moderated by Susan Frankel

The afternoon featured four, approximately 30 minute presentations followed by an equal time for discussion.

Impacts of Climate Change for Drought and Wildfire: Faith Ann Heinsch, University of Montana, faithann@ntsg.umt.edu

Summary

Heinsch provided a general overview of climate change science explaining, in brief, the findings of the Intergovernmental Panel on Climate Change (IPPC). The physical science basis for climate change; impacts, adaptation and vulnerability; and mitigation were introduced.

Carbon Credit Projects in the Forestry Sector: What is Being Done to Manage Carbon? What Can Be Done?

Keegan Eisenstadt, CEO, ClearSky Climate Solutions, Missoula, MT; www.clearskyclimatesolutions.com, keegan@clearskyclimatesolutions.com

Summary

Eisenstadt presented the rationale and challenges for carbon credits and markets for the forestry sector. He outlined several of Clear-Sky's carbon credits projects: the Panama sustainable forestry and re-forestation project, Gordondale Dairy Methane Capture Project, Pinehurst Acres Methane Capture Project, Texas Re-forestation Project Pool and the Montana Rangeland Carbon Sequestration Project Pool. Discussion centered on whether purchasing credits really made a difference in carbon budgets and how fire, diseases and other disturbances could derail the carbon sequestration goal.

Judy Adams and Blakey Lockman

Mountain Pine Beetle and Eastern Spruce Budworm Impacts on Forest Carbon Dynamics

Caren Dymond[1]

Abstract

The mountain pine beetle (*Dendroctonus ponderosae* Hopkins, Coleoptera: Curculionidae, Scolytinae) is a native insect of the pine forests of western North America, and its populations periodically erupt into large-scale outbreaks. During outbreaks, the resulting widespread tree mortality reduces forest carbon uptake and increases future emissions from the decay of killed trees. The impacts of insects on forest carbon dynamics, however, are generally ignored in large-scale modelling analyses. The current outbreak in British Columbia, Canada, is an order of magnitude larger in area and severity than all previous recorded outbreaks.

Here we estimate that the cumulative impact of the beetle outbreak in the affected region during 2000–2020 will be 270 megatonnes (Mt) carbon (or 36 g carbon m^{-2} yr^{-1} on average over 374,000 km^2 of forest). This impact converted the forest from a small net carbon sink to a large net carbon source both during and immediately after the outbreak. In the worst year, the impacts resulting from the beetle outbreak in British Columbia were equivalent to ~ 75% of the average annual direct forest fire emissions from all of Canada during 1959–1999. The resulting reduction in net primary production was of similar magnitude to increases observed during the 1980s and 1990s as a result of global change. Climate change has contributed to the unprecedented extent and severity of this outbreak. Insect outbreaks such as this represent an important mechanism by which climate change may undermine the ability of northern forests to take up and store atmospheric carbon, and such impacts should be accounted for in large-scale modelling analyses.

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[1]In: Baker, F.A. comp. 2008. Proceedings of the 56th Western International Forest Disease Work Conference; 2008 October 27-31; Missoula, MT. Logan, UT: USU Dept. of Wildland Resources.

[1]Caren Dymond, BC Ministry of Forests, Caren.Dymond@gov.bc.ca. Dymond presented an oral version of WA Kurz, CC Dymond, G Stenson, GJ Rampley, AL Carroll, T Ebata, L Safranyik. 2008. Mountain pine beetle and forest carbon feedback to climate change. Nature. 452: 987-990. http://www.nature.com/ nature/journal/v452/n7190/full/nature06777.html.

Big bus on a little road – going to field trip site

Climate Change Influence on Wood Decay

Robert L. Edmonds[1]

Abstract

A large biomass of wood exists in living trees and standing dead and downed trees in western North American forests. This biomass is decayed by lignicolous fungi as part of the natural carbon and nutrient cycles. The majority of these fungi are basidiomycetes. Climate change will strongly influence the decay rates of woody biomass which will affect the ecology and carbon storage capacity of western forests. This paper explores the evidence for climate change in the Pacific Northwest, the influence of climate change on forest ecosystems, the diversity of fungi causing wood decay, the ecological importance of brown versus white rot fungi, the effects of forest management on woody decay fungi, and the influence of global warming on fungi and wood decay. Global warming and changes in precipitation will increase the decay rate of wood decay fungi in western North America. Wood decay rates will increase at higher latitudes and elevations. Fruiting patterns and spore production will also change. There is a large biodiversity wood rotting fungi in North America (1669 species); 94% are white rot fungi. However, most brown rot fungi typically decay conifer wood and ecologically important. Because of the potential replacement of conifers with hardwoods with global warming and the relatively low number of species of brown rot fungi compared to white rot fungi, some species of brown rot fungi could go extinct.

Introduction

There is a considerable biomass of wood in forest ecosystems in western North America associated with living, standing dead and downed trees. In old-growth conifer forests it is typically more than 90% of the total biomass (Edmonds et al. 1998). Large dead wood (> 10 cm in diameter), commonly called coarse woody or logs (i.e., CWD). Many invade living trees to decay heartwood. Some species can kill trees, particularly debris (CWD), makes up most of the biomass, but small twigs and branches also make up the woody biomass on the forest floor. After conifer trees die they may take 600 years or longer to decay, depending on their diameter and the fungi that decay them. Most lignicolous, or wood decay fungi, are saprophytes on dead wood, including standing dead and downed trees those decaying woody roots. Stem decay fungi may weaken trees to the point of failure, particularly in wind storms, indirectly contributing to tree death. After trees die many of these fungi can survive for a long time in the wood of dead trees and some can survive for more than 100 years.

Wood decay fungi are ecologically important, contributing CO_2 to the atmosphere and organic matter to soil, as well as providing plant and wildlife habitat. Interestingly, they occur in all ecosystems with wood, including deserts (Gilbertson 1980). Wood decay fungi play a vital role in recycling the carbon and nutrients locked up in wood (Gilbertson 1980). However, their role in carbon cycling seems to be more important than that in nutrient cycling, since nutrient concentrations are generally low in wood, particularly CWD. In fact, Laiho and Prescott (2004) suggest that there is little evidence that CWD plays an important role in nutrient cycling in northern coniferous forests. CWD contributes <10% of nutrients (N, P, K, Ca, Mg) returned annually in aboveground litter and about 5% of the N and P released annually from decomposing litter or soil (Laiho and Prescott 2004).

Many factors influence wood decay including, tree species and associated substrate chemistry, the fungal species involved, insects (particularly beetles), oxygen levels, and climate (temperature and moisture). Decomposition of wood by fungi in forest ecosystems is strongly influenced by temperature and moisture (Harmon et al. 1986). Thus climate change can be expected to influence pathogenic and saprophytic wood decay fungi and wood decay rates (Kliejunas et al. in preparation)

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[1]Robert L. Edmonds, College of Forest Resources, University of Washington, Seattle, WA 98195

In this paper I explore the evidence for climate change in the Pacific Northwest, the influence of climate change on forest ecosystems, the diversity of fungi causing wood decay, the ecological importance of brown versus white rot fungi, the effects of forest management on woody decay fungi, and the influence of global warming on fungi and decay.

Evidence for Climate Change in the Pacific Northwest

While climate patterns have shifted markedly even over the past 1000 years, current variations in climate are occurring exponentially faster than historic shifts did (Peterson et al. 1997). Until recently humans had little influence on the Earth's climate, but there is now little doubt that human activities have caused global change through the production of greenhouse gases, such as CO_2 and CH_4. The average global temperature increased approximately 0.6°C over the past century (IPCC 2007). The bulk of the warming has occurred at high latitudes, over continents, at night, and in the winter season. General Circulation Models forced with increasing greenhouse gas concentrations predict gradual warming near the Earth's surface of 1.5° to 6° C (globally averaged) by 2100 (Hansen et al. 2001), but the response may not be linear and warming could be more rapid in some areas.

The Pacific Northwest has seen a temperature increase of 0.8° C during the 20th century, and further temperature increases by 1.5° C, and 2.3° C are expected by the 2020s and 2040s, respectively (Peterson et al. 1997, Mote et al. 2003). This will likely equate to more rainfall in the winter with less snow pack, and a more defined dry season during the summer months (Mote et al. 2003). While coastal regions are predicted to experience less severe impacts from climate change, current models show a slight drying trend in the Northwest United States (Aber et al. 2001, Harvell et al. 2002). The Northwest region is expected to experience increased rainfall except in the summer, and an overall decrease in winter snow pack, which may lead to further summer drought stress (Mote et al. 2003).

Examination of the actual temperature and precipitation data on a state-wide basis from Washington, Oregon, Idaho, Montana, Colorado and California (NOAA 2008) from 1895 to 2007, reveals a trend of increasing average annual air temperatures in all of these states; about 0.3 to 0.5° C in Oregon, Washington, and California with greater increases (0.6 to 1.0° C) in the inland states of Idaho, Montana and Colorado. Precipitation has increased in Washington and Oregon, but decreased in California, Idaho, Montana and Colorado. There appears to be little doubt that the climate in the Pacific Northwest has changed over the last 100 years, and particularly in the last 10 years. This trend is sure to continue and will strongly influence organisms in ecosystems.

Influence of Climate Change on Ecosystems and Vegetation

With changes in temperature and precipitation in North America it is believed that current conifer dominated forests will change to have a greater broadleaf component. Broadleaved hardwoods that are currently limited by cold temperatures will spread northwards and replace conifers as the climate warms (Shafer et al. 2001). Also lowland forest communities will shift higher in elevation. This will have serious consequences for existing high elevation, subalpine, and alpine forests (Peterson et al. 1997, Thompson et al. 1997, Aber et al. 2001, Hansen et al. 2001). Thompson et al. (1997) suggested that in a 2xCO_2 climate scenario high elevation tree species such as Engelmann spruce would decrease its range. Douglas-fir and lodgepole pine would also generally decrease, although there may be increases in ranges for Douglas-fir in the southwestern United States and for lodgepole pine in the Puget Sound area and the Willamette Valley. In contrast, ponderosa pine would increase its range, particularly in the Rocky Mountain States. Pinyon pine, a species typical of the dry southwest is predicted to increase its range to include Washington, Oregon, and Montana and be reduced in its current range. Ranges for California white oak, Gambel oak and Oregon white oak would also increase dramatically. Such range changes related to global change may result in novel ecosystems with new combinations of species (Seastedt et al. 2008). Species will not just respond in lock step to climate

change and plant associations (the combination of overstory and understory plants) as we currently know them may change completely.

Tree species changes are likely to occur on a time scale of tens to hundreds of years (Shaver et al. 2000) since migration of tree species is a relatively slow process. Other processes associated with vegetation, such as photosynthesis respond on a much shorter time scale from days to years, and microbes, including wood decay fungi, can also respond on a relatively short time scale from years to decades (Shaver et al. 2000). Thus the processes and organisms in ecosystems will respond to global change over different time and space scales, sometimes in ways that are difficult to predict.

The Diversity of Fungi Causing Wood Decay

A large number of fungal species cause wood decay in North American ecosystems (Gilbertson 1980). Most species are basidiomycetes but there are a few ascomycetes in the family Xylariaceae (Gilbertson 1980). Most do not act alone in woody substrates and may not be able to invade wood without alteration by hyphomycetes, bacteria or yeasts.

Gilbertson (1980) reported the presence of 1669 species of wood rotting fungi in North America: 101 species in the order Tremellales (jelly fungi), 948 species in the order Aphyllophorales and 620 species in the Agaricales. It is possible that more species exist in the North America than have been reported. As far as we know all species are endemic. However, exotic fungal species have been reported decaying wooden structures.

The distribution of North American wood rotting fungi is related to the distribution of host plants (Gilbertson 1980). However, species of wood decay fungi are generally more widely dispersed than species of higher plants. For example, *Fomitopsis pinicola* occurs in both Europe and North America. But some like *Echinodontium tinctorium* only occur only in western North America even though suitable hosts (balsam fir and Fraser fir occur in the east) (Gilbertson 1980).

Decay is typically described by where it occurs (e.g., root rots, saprots, and heartrots of living trees, and decay in standing trees and downed logs). Some of the fungi causing decay have broad host ranges, while others are restricted to a few host species. Common basidiomycetes in western North America occurring in roots of living trees are *Armillaria ostoyae, Phellinus weirii, Heterobasidion annosum*, and *Phaeolus schweinitzii. Ganoderma applanatum*, *Laetiporus sulphureus*, *Echinodontium tinctorium*, *Fomitopsis officinalis*, *Phellinus hartigii*, and *P. pini* are common rotters of heartwood in living trees (Sinclair and Lyons 2005). Heart rot fungi provide wildlife habitat for cavity nesting birds, bats, and small mammals, alter vegetation diversity, and speed structural differentiation (Hennon 1995, Bull et al. 1997). Saprotters include many *Stereum* spp. and *Cryptoporus volvatus*. In standing dead trees and downed logs *Fomitopsis pinicola* tends to dominate, but other fungi, such as *Perenniporia subacida* and the mushroom *Hypholoma fasciculare* can be quite common.

The Ecological Importance of Brown and White Rot Fungi

White rot fungi decompose both cellulose and lignin, while brown rot fungi decompose only cellulose leaving brown cubes of lignin. *Heterobasidion annosum, Armillaria* spp., *Phellinus weirii*, *Ganoderma applanatum, Perenniporia subacida,* and *Phellinus pini* cause white rot, while *Laetiporus sulphureus, Fomitopsis officinalis*, and *Fomitopsis pinicola* cause brown cubical rot (Gilbertson 1980). Ecologically, brown and white rot fungi perform different roles. Brown rotters allow CWD to function as nurse logs and wildlife habitat and a source of invertebrate and microbial diversity. For example, a Douglas-fir tree may live for 600 years. Once it dies and reaches the forest floor it potentially has a “life” for another 600 years as CWD because of brown rot fungi such as *Fomitopsis pinicola*. If the CWD was decayed by a white rot fungus, it would decay much faster and structurally not be able to support plants growing on it. It would also not be as attractive as habitat for wildlife, such as voles. Initially brown rot fungi cause greater weight loss in wood than white rot fungi, but not over decades or centuries. Many birds,

such as wood peckers and cavity nesters, exploit decay in living trees caused by both brown and white rot fungi (Bull et al. 1997).

There are fewer brown rot fungi (106 spp.) than white rot fungi (1563 spp.); only 6% of the total. Gilbertson (1980) suggested that brown rot fungi evolved from white rot fungi. The majority of brown rot fungi are in the Polyporaceae and most are associated with conifers while white rot fungi can decay both conifers and hardwoods.

Effects of Forest Management on Wood Decay Fungi

Forest management removes wood from the forest to be used for timber products and heating and more recently for biofuels. Small diameter and cull wood, including stumps, and other CWD are typically left behind, but much of this is burned either accidently or on purpose to reduce fuels for forest fires. Logging activities typically disrupt wood on the forest floor increasing the rate of wood decomposition. Forests replanted after cutting old-growth trees are typically grown on successive rotations of less than 100 years resulting in smaller diameter trees. Thus for many reasons forest management has reduced CWD in many ecosystems, particularly the largest diameter wood. This could result in loss of wood rotting fungal species with time. Hardwood plantations of red alder and poplar are also becoming more numerous. An increase of hardwoods relative to conifers could also reduce brown rotting fungi. Furthermore, forest management also increases tree growth rates and the resulting wood may be more susceptible to decay. For example, Edman et al. (2006) found that fast-grown Norway spruce had a 50% faster decay by *Fomitopsis pinicola* than slower-grown Norway spruce. Climate change and forest management will interact to influence wood decay rates.

Influence of Global Warming on Wood Decay Fungi

Wood decay fungi will respond to changing temperature and moisture conditions. Modeling studies suggested that an increase in regional warming and drying in the west would result in increased decomposition of CWD except in very dry conditions (Yin 1999). If decomposition increases then the contribution of wood decay fungi to CO_2 evolution will also increase further changing temperature and moisture conditions. Interestingly, we have given little thought as to how CO_2 is evolved from decayed wood. Wood decay fungi typically grow in aerobic conditions, but the growth of fungi in wood may actually induce strong hypoxia or even anoxia (Mukkin et al. 2006). They suggest that wood decay fungi like *Fomitopsis pinicola* utilize their fruiting bodies as the fungal lungs, taking in the oxygen needed to grow in an almost anaerobic environment and respiring CO_2 to the atmosphere. Mukkin et al. (2006) found that very little CO_2 leaves through the wood compared to fruiting bodies. This may explain to some extent why *Fomitopsis pinicola* produces so many fruiting bodies on standing dead and downed trees.

The impact of global temperature change threatens to disrupt the current balance that exists between wood in ecosystems and wood decay fungi. Recent research has acknowledged the serious impact that global climate change can have on disturbance regimes, potentially exacerbating current forest health issues (He et al. 1999, Dale et al. 2001). More stress in western forests may prove to increase pathogen and insect mortality. Certainly the mountain pine beetle has recently created large amounts of dead wood in western Canada on a rarely seen scale. Increases in winter temperature have been blamed for allowing beetle populations to dramatically increase.

Wood decay fungi respond directly to temperature. On average the optimum temperature for growth is about 28^{o} C (Gilbertson 1980). However, it can be as low as 20° C and as high as 38° C. Some fungi appear to have particular niches related to temperature. For example, *Gleophyllum saeparium* has a temperature optimum of 38° C (Loman 1965) and commonly grows on small diameter wood in hot clear cut areas, where few other wood decay fungi are found. Interestingly it is difficult to find temperature growth curves in the literature for many North American wood decay fungi. Typically, the linear growth rate of wood decay organisms in culture like *Heterobasidion annosum* stops at 0° C, slowly increases to a maximum, and then declines swiftly. This is clearly shown in figure 1 for two isolates of *Heterobasidion annosum* from western Washington (Edmonds 1968). Both have an optimal growth temperature of about 25° C. A higher optimum temperature could have been found had these isolates been grown at 1° C

temperature increments instead of 5° C. Growth stopped abruptly at 30° C. There is considerable variation among isolates as shown here with one isolate growing almost twice as fast as the other at 25° C. A similar linear growth pattern in culture was shown for *Fomitopsis pinicola* isolates from western Washington from 0 to 20° C (Antos 1978). He examined linear growth of isolates from low and high elevation locations and found that low elevation isolates grew faster than lowland isolates at 20 ° C, suggesting that isolates may adapt to the temperature conditions they evolved in.

Temperatures in wood typically are much cooler than air temperatures so wood temperatures are typically below average air temperatures in many forest ecosystems in North America throughout the year. Thus it would be expected that global warming will increase the growth of wood decaying fungi at high latitudes and elevations. Kueppers et al. (2004) examined woody biomass and decay rates along an elevation gradient and suggested that warming will lead to a loss of dead wood carbon from subalpine forests.

However, at lower latitudes in drier environments the growth of wood decay fungi could be inhibited. Periodic high temperatures could also be lethal (Loman 1965). On the other hand an increase in winter temperatures may allow decay fungi to function for longer periods of time during the year.
Some fungi could expand their range with global warming, while others may have reduced ranges. This will also depend on the availability of suitable woody substrates.

Mackensen et al. (2003) examined decay rates of coarse woody debris in both the northern and southern hemispheres and found that temperature explained about 34% of the variation in decay rates. Interestingly they found that maximum decay occurred at 25° C.

Moisture is also important, but Mackensen et al. (2003) found that CWD decay rates did not increase with increasing precipitation. Maximum decay rates occur in areas with annual precipitation of 1000 mm year with declining rates in drier and wetter conditions. Decay rates where precipitation is >2500 mm/yr are typically lower than those where precipitation is 500 mm/yr. Decay fungi cannot degrade wood with moisture contents less than 30 % on a dry-mass basis (the fiber saturation point). Also moisture contents greater than 90% inhibit decomposition due to lack of oxygen (Griffin 1977). There is a strong interaction between temperature and precipitation effects on wood decomposition.

Global change can also affect fungal fruiting, and thus spore production and dispersion to new substrates. Gange et al. (2007) analyzed fungal fruiting records from 315 fungal species, including wood decay fungi in 1400 locations in southern England over a 56-year period from 1950-2005. They noted that the first fruiting date is now earlier and last fruiting date is later due to increases in late summer temperature and October rainfall. Many species now fruit in spring as well as fall. They suggested that the mycelium of certain species must be active in late winter and early spring as well as late summer and autumn, implying an increase in decay rates in forests. Unfortunately, there are no data similar data on fungi in western North American forests for comparison, but similar trends would be expected in response to global change.

A further influence of global change on wood decay fungi is related to changes in tree species and wood types. Global change may increase the hardwood component of western forests and thus increase the white rot fungi relative to brown rotters that prefer conifer wood. With an overall increase in white rot fungi, carbon storage rates in forests could be reduced with accelerating carbon breakdown because white rot fungi can utilize both cellulose and lignin.

Conclusions

There is high biodiversity of wood decay fungi in North America. Each species has its own ecological niche with respect to temperature and moisture, tree species, tree component, living or dead wood and wood diameter. With changes in temperature and precipitation in North America broadleaved hardwoods that are currently limited by cold temperatures will spread northwards and replace conifers as the climate warms. Also lowland tree species will shift higher in elevation. Wood decay fungi are capable of responding more quickly to global warming than vegetation.

Generally it is thought that global warming and changes in precipitation will increase wood decay

rates in western North America, but this depends on the ecosystem. Wood decay rates will probably increase at higher latitudes and elevations. Fruiting patterns and spore production of wood rotting species will also change. Brown rot fungi typically decay conifers rather than hardwoods. Because of the potential replacement of conifers with hardwoods with global warming, and the relatively low number of species of brown rot fungi compared to white rotters, some species of brown rot fungi could go extinct. With an overall increase in white rot fungi, carbon storage rates will reduced. This will be further exacerbated by forest management since woody residues will continue to decline with increased use of wood for timber, heating and biofuels.

References

Aber, J., Neilson, R.P., McNulty, S.J., Lenihan, M., Bachelet, D., Drapek. R.J. 2001. Forest processes and global environmental change: predicting the effects of individual and multiple stressors. BioScience 51(9): 735-751.

Antos, G.C. 1978. Fungal population dynamics within the forest floors in Pacific silver fir, western hemlock, Douglas-fir, and red alder ecosystems in Washington, MS thesis, University of Washington, Seattle.

Bull, E.L., Parks, C.G., Torgeson, T.R. 1997. Trees and logs important to wildlife in the interior Columbia River Basin. General Technical Report, PNW-GTR-391, USDA Forest Service, Pacific Northwest Research Station.

Dale, V.H., Joyce, L.A., McNulty, S. ,Neilson, R.P., Ayres, M.P., Flannigan, M.D., Hanson, P. J., Irland, L.C., Luga, A.E., Peterson, C.J., Simberloff, D., Swanson, F.J., Stocks, B. J., Wotton. B. M. 2001. Climate change and forest disturbances. BioScience 51(9): 723-734.

Edman, M., Moller, R., Ericson, L. 2006. Effects of enhanced tree growth rate on the decay capacities of three saprotrophic wood-fungi. Forest Ecology and Management 232(1-2): 12-18.

Edmonds, R.L. 1968. Natural occurrence and control of *Fomes annosus* in precommercially thinned stands of western hemlock**,** MS thesis, University of Washington, Seattle.

Edmonds, R.L., Blew, R.D., Marra, J.L., Blew, J., Barg, A.K., Murray, G., Thomas, T.B. 1998. Vegetation patterns, hydrology, and water chemistry in small watersheds in the Hoh River Valley, Olympic National Park. Scientific Monograph NPSD/NRUSGS/NRSM-98/02. USDI, National Park Service.

Gange, A.C., Gange, E.G., Sparks, T.H., Boddy, L. 2007. Rapid and recent changes in fungal fruiting patterns. Science 316: 71.

Gilbertson, R.L. 1980. Wood-rotting fungi of North America. Mycologia 72: 1-49.

Griffin, D.M. 1977. Water potential and wood-decay fungi. Annual Review of Phytopathology 15: 319-329.

Hansen, A.J., Neilson, R.P., Dale, V.H., Falter, C.H., Iveson, L.R., Currie, D.J., Shafer, S., Cook, R., Bartlein. P.J. 2001. Global change in forests: responses of species, communities and biomes. BioScience 51(9): 765-779.

Harmon, M.H., Franklin, J.F., Swanson, F.J., Sollins, P., Gregory, S.V., Lattin, J.D., Anderson, N.H., Cline, S.P., Aumen, N.G., Sedell, J.R., Lienkkaemper, G.W., Cromack, K. Jr., Cummins, K.W. 1986. Ecology of coarse woody debris in temperate ecosystems. Advances in Ecological Research 15:133-302.

Harvell, C.D., Mitchell, C.E., Ward, J.R., Altizer, S., Dobson, A.P., Ostfeld, R.S., Samuel, M.D. 2002. Climate warming and disease risks for terrestrial and marine biota. Science 296: 2158-2162.

He, H.S., Mladenoff, D.J., Crow, T.R. 1999. Linking an ecosystem model and a landscape model to study forest species response to climate warming. Ecological Modeling. 114: 213-233.

Hennon, P.E. 1995. Are heart rot fungi major factors of disturbance in gap-dynamic forests? Northwest Science 69(4): 284-293.

IPCC (Intergovernmental Panel on Climate Change). 2007. Summary for policymakers. The physical science basis. Contribution of Working Group I to the Fourth Assessment Report of IPCC, Cambridge University Press, Cambridge, UK and New York, NY. http://www.ipcc.ch/pdf/assessment-report/ar4/syr/ar4_syr_spm.pdf.

Kliejunas, J.T. Geils, B., Glaeser, J.M., Goheen, E.M., Hennon, P., Kim, M.S., Kope, H., Stone, J., Sturrock, R., Frankel, S.J. In preparation. Climate and forest diseases of western North America: A literature review. General Technical Report, PSW-XXX, USDA Forest Service, Pacific Southwest Research Station, Albany. 36 p. http://www.fs.fed.us/psw/topics/climate_change/forest_disease/Final.Forpathandcc.lit.jk.2008.09.24.pdf.

Kueppers, L.M., Southin, J., Baer, P., Harte, J. 2004. Dead wood biomass and turnover time, measured by radiocarbon, along an elevational gradient. Oecologia 141: 641-651.

Laiho, R., Prescott, C.E. 2004. Decay and nutrient dynamics of coarse woody debris in northern coniferous forests: a synthesis. Canadian Journal of Forest Research. 34: 763-777.

Loman, A.A. 1965. The lethal effect of periodic high temperatures on certain lodgepole pine slash decaying basidiomycetes. Canadian Journal of Botany 43: 334-338.

Mackensen, J., Bauhus, J., Webber, E. 2003. Decomposition of coarse woody debris-a review with particular emphasis on Australian tree species. Australian Journal of Botany 51: 27-37.

Mote, P.W., Parson, E., Hamlet, A.F., Keeton, W.S., Lettenmaier, D., Mantua, N., Miles, E.L., Peterson, D., Peterson, D.L., Slaughter, R., Snover. A.K. 2003. Preparing for climate change: The water, salmon, and forests of the Pacific Northwest. Climate Change 61(1-2): 45-88.

Mukkin, V.A., Voronin, P. Yu, Ladatko, V.A., Ivanov, A.N. 2006. The oxygenic and cooperative respiration of the wood-decaying fungus Fomitopsis pinicola (Sw.:Fr) Pers. Duklad Biological Sciences 407: 153-154.

NOAA (National Oceanic and Atmospheric Administration). 2008. U.S. statewide analysis. NOAA Satellite and Information Service. National Climatic Data Center, U.S. Department of Commerce. http://lwf.ncdc.noaa.gov/oa/climate/research/cag3/state.html.

Peterson, D.L., Schreiner, E.G., Buckingham. N.M. 1997. Gradients, vegetation and climate: spatial and temporal dynamics in the Olympic Mountains, USA. Global Ecology and Biogeography Letters 6(1): 7-17.

Seastedt, T.R., Hobbs R. J., Suding. K.N. 2008. Management of novel ecosystems: are novel approaches required. Frontiers in Ecology and the Environment 6(10): 547-553.

Shafer, S.L., Bartlein, P.J., Thompson, R.S. 2001. Potential changes in the distributions of western North American tree and shrub taxa under future climate scenarios. Ecosystems 4: 200-215.

Shaver, G.R., Canadell, J., Chapin, F.S. III, Gurevitch, J., Harte, J., Henry, G., Ineson, O., Joanasson, S., Melillo, J., Pitelka, L., Rustad, L. 2000. Global warming and terrestrial ecosystems: a conceptual framework for analysis. BioScience 50(10): 871-882.

Sinclair, W.A., Lyons, H.H. 2005. Diseases of Trees and Shrubs. Second Edition. Comstock Publishing Associates, Ithaca, NY. 660 p.

Thompson, R.S., Anderson K.H., Bartlein. P.J. 1997. Assessment of potential future vegetation change in the southwestern United States. In Impact of climate change and land use in the southwestern United States. USGS Global Change Program. http://geochange.er.usgs.gov/sw/index.html.

Yin , X. 1999. The decay of forest woody debris: numerical modeling and implications based on 300 data cases from North America. Oecologia 121: 81-98.

Carlton Ridge Hike, Bitterroot National Forest

Panel: Invasive Species - Learning by Example

Moderated by Ellen Goheen

The afternoon featured four, approximately 30 minute presentations followed by an equal time for discussion.

Is Firewood Moving Tree Pests? By: William Jacobi, Department of Bioagricultural Sciences and Pest Management, Colorado State University.

If We Knew Then What We Know Now: *Raffaelea lauricola*, the Cause of Laurel Wilt in the Southeastern US. By: Bruce Moltzan, USDA Forest Service, Forest Health Protection, Washington DC.

Montana Bear Attack Pathologists

Phytophthora alni: Early Lessons from Alaska

Lori Trummer[1]

Alaska is at the beginning stages of attention surrounding the first North American findings of *Phytophthora alni* subspecies *uniformis* (PAU). We've already learned some important lessons regarding communications, partnering, and funding.

As many of you are aware, PAU was first found in Alaska in 2007 during stream and soil surveys across the south-central and interior regions. These surveys were initiated during a series of long-term studies on the widespread dieback and mortality of several alder species in Alaska.

By spring 2008, three PAU isolates were confirmed at two locations approximately 400 miles apart. This is the first time that PAU was confirmed in North America. As many of you well know, this sparked much interest nationally as well as worldwide. By January 2009, we had 10 isolates of PAU, to date, across 7 sites and 1,000 road miles, plus findings of a new, yet unnamed *Phytophthora* in Clade 8C, the Clade which includes forest pathogens such as *P. ramorum*. Also, isolates of forest tree pathogenic species have been found, including *P. gallica*, *P. pseudosyringae*, and *Pythium undulatum*. Isolates of *P. hungarica* have also been found.

The first paper regarding the PAU finding in Alaska has been published in Plant Health Progress. I don't want to focus too much on the specifics of these findings, which can be tracked on the Alaska Forest Service webpage at www.fs.fed.us/r10/spf/fhp quickpick Alder *P.alni*. Rather, I would like to address some of the lessons learned to date.

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Here are six simple lessons and suggestions for mitigating them:

1. Sole Proprietor Phenomenon?
   ➤Partnership, Partnership, Partnership!
2. Reinventing the wheel?
   ➤Don't!
3. Lack of interest by Partners (state, federal, etc.)?
   ➤Seek common goals
4. Challenging funding avenues?
   ➤Seek multiple funding opportunities
5. Slow laboratory confirmation?
   ➤Seek new methods/new partnerships to decrease laboratory confirmation time
6. Is Alaska in the United States?
   ➤Carry a map of Alaska at all times!

Sole Proprietor Phenomenon

As many of you know, I am the one forest pathologist (counting all State, Federal, University or Private) for south-central and interior Alaska. This is an enormous jurisdiction, nearly one-third the size of the continental US. To adequately cover such a territory, it is essential to be the main cheerleader to raise interest, money, and provide multi-agency coordination and communication. It was immediately apparent that this finding would be a large task on top of an already full plate.

It was critical early on to find assistance and develop partnerships both inside and outside the state. Also, to improve communication channels, a webpage was developed with regular updates. It is up, running, and regularly updated at: www.fs.fed.us/r10/spf/fhp ....Quick Pick: Alder *P.alni*

Reinventing the wheel?

Thankfully, thankfully, there is no need to reinvent the wheel. A current literature search reveals a tremendous amount of information on similar new "findings". For us, there was a large cadre of very helpful and knowledgeable Sudden Oak Death and

Phytophthora researchers including: Susan Frankel, Ellen Goheen, Steve Oak, Everett Hansen, Mary Palm, Susan Diehl, Thomas Jung, Joan Webber, Thomas Cech, and Clive Brasier.

Lack of interest by Partners (state, federal)

In Alaska, the initial responses of APHIS, State Division of Agricultue, and State Division of DNR were lackluster. These staffs were already burdened or over-burdened with many unfunded problems. They viewed the findings as non-regulatory (intra and interstate transportation of alders was considered practically non-existent) and not their problem. Lack of personnel, other priorities, and declining funding to handle their existing workloads were cited as additional reasons for their unenthusiastic response.

Luckily we all persevered to find common ground in public education and communication regarding this issue. We co-wrote a handout for annual Nurseryman's conference in January 2008, and the topic is on the agenda for the 09 conference.

Indeed, the finding of a new *Phytophthora* in Clade 8C helps to illustrate overcoming the perceived lack of relevance of these findings. Due to the similarities between the new *Phytophthora* and *P. ramorum* (both in Clade 8C), *P. ramorum* research labs in Canada, Germany, United Kingdom, France, Netherlands and USA APHIS have all urgently requested cultures of the new *Phytophthora* for continuing and improving their research on detection assays.

Unfortunately some problems have yet to be solved. Tension remains between the nursery industry and invasive species researchers at some institutions. Trust among and between entities can be difficult to obtain and uphold when priorities shift and funding is scarce. There is also some difficult challenges with APHIS permit issues.... including obtaining the required permits to take roots or soil out of state. At this juncture, APHIS only allows soil samples to be transported to a fully equipped soils analysis laboratory.

Gerry Adams (R) and Alaska Technician Chris Scott excavating one of 100 alders in summer 08

Challenging funding avenues to navigate

Alaska was well funded by the Forest Service to look for Phytophthoras. It was, however, much more challenging to find partner funds after we found something! This was quite surprising. It can be a vicious circle to find funding for "potentially native unknown plant pathogens". The story we often received from local partners was, "If you tell us the whole story and its relevance, we may be able to find some money for you". Unfortunately, we needed dollars up front to carefully assess the findings and answer their questions! Money to help clarify the real nature of the findings was indeed the scarcest type to find.

In spite of this, gold stars should be awarded to the Forest Service, particularly Rob Mangold, Borys Tkacz, and Bruce Moltzan for their unfailing support to Alaska and

Susan Frankel for being a tireless force of advice and encouragement for me.

Slow laboratory confirmation

It took at least six months from the initial sample collection in August 2007 to complete independent DNA and culture confirmation. We are now partnering with other laboratories to help quickly process large amounts of samples. Everett Hansen at OSU has been of tremendous assistance on cleaning and processing the 2008 samples.

Is Alaska in the United States?

A perennial issue for Alaska is the fact that we are frequently left off of maps showing the 48 contiguous states, or relegated to a tiny corner. Unfortunately this also means that our state, at times, is also left off of national projects. For instance, Alaska was not initially on the Forest Service's *Phytophthora alni* Risk Map for the United States. This oversight has now been corrected.

As a tireless advocate for all things Alaskan, I suggest carrying a map of the state in your back pocket at all times!

The gang on the Carlton Ridge Day Hike 2008

If We Knew Then What We Know Now: *Raffaelea lauricola,* the Cause of Laurel Wilt in the Southeastern U.S.

Bruce Moltzan[1]

Laurel wilt caused by the fungus *Raffaelea lauricola* vectored by an introduced ambrosia beetle *Xyleborus glabratus* is a serious wilt disease of Redbay (*Persea borbonia*). Widespread mortality in Redbay has been occurring along its coastal range in South Carolina, Georgia, and Florida since 2003. The connection between the pathogen and the beetle through field isolation and controlled inoculations on and with Redbay, sassafras, and avocado was demonstrated in 2005 and hence the heretofore-undescribed *Raffaelea* sp. isolated from *X. glabratus* properly named in 2008. Nearly all-mature Redbays have died in affected areas within 2-5 years. Laurel wilt disease has spread rapidly and represents a threat to other Lauraceous plants in the Americas with potential for extending its range through the more widely distributed sassafras. The lessons learned from the current outbreak are not to underestimate previously assumed non-threatening beetle detections and their fungal associates; consider broader fungal screening for all newly detected non-native insects in the US and abroad; findings should be adapted quickly to management practice as they become available. Finally, given Dutch Elm Disease, White Pine Blister Rust, Chestnut Blight, Sudden Oak Death, Bacterial Leaf Scorch, Dogwood Anthracnose, Pine Wilt Nematode, Butternut Canker, Phytophthora Root Rot, Brown Root Rot, European Larch Canker are all listed in the Global Invasive Species Database a strong case can be made for the inclusion of Laurel Wilt. (**http://www.issg.org/database/welcome/).**

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[1]Bruce Moltzan, USDA Forest Service, Forest Health Protection, Washington DC

Application of GIS Models as a Decision Tool for Continued Eradication of Citrus Canker Epidemics in an Agro-urban Landscape

Tim Gottwald[1]

Asiatic Citrus canker (ACC, caused by *Xanthomonas citri* ssp. *citri*) is spread by rain splash combined with wind and is greatly exacerbated by tropical storms and hurricanes. The disease will be used as an example to explore the regulatory decision making process relative to the feasibility of continued eradication in an agro-urban landscape, that is, during plant disease epidemics driven by and interaction of urban residential plants, and commercial agricultural plantings of the same species. ACC is primarily a leaf and fruit spotting disease characterized by erumpent lesions on fruit, foliage, and young stems of susceptible cultivars of citrus. Most commercial citrus varieties are moderately to highly susceptible to the disease. When the disease is severe, defoliation, dieback and fruit drop can occur and infected fruit that remain are less valuable or entirely unmarketable. The ACC epidemics are exacerbated by the Asian citrus leafminer, *Phyllocnistis citrella*, introduced to Florida in 1993 and to Brazil in 1996. Citrus canker has increased significantly as a consequence of the insect's feeding activities which create wounds that expose leaf mesophyll tissues to splashed inoculum, thus increasing the probability of infection.

ACC presently exists in the majority of commercial citrus production regions of the world and in the Americas has plagued multiple States in the Southeastern US, as well as Argentina, Bolivia, Brazil, Chile, Paraguay, and Uruguay. Florida has endured three citrus canker epidemics over the last 100 years. Although canker first affected the Florida citrus industry in 1910, it was eradicated by the 1930s after massive removals of infected trees. However, ACC was discovered a second time in Florida in 1986 and was declared eradicated in 1992, but was discovered a third time in Florida in residential citrus in Dade County in 1995 in a 14 sq. mile area south of the Miami International Airport. The most recent joint State/Federal Citrus Canker Eradication Program (CCEP) ended in 2006 after 10 yrs and a total cost of $1 billion. The program was plagued by legal conflicts between the CCEP and residential homeowners who felt that the regulatory actions being taken protected the citrus industry at too high a cost to residential citrus tree owners. The numerous injunctions and appeals led to a discontinuous and sporadic eradication program. As the legalities of eradication were debated, the disease continued to spread, and outbreaks in new commercial and residential areas erupted across Florida. Although the press and a few outspoken residents claim it was a failure, it was not. The program held off ACC and gave the citrus industry freedom from statewide quarantines and national/international marketing restrictions for those 10 yrs.

Hurricanes and tropical storms in Florida have been associated with long-range dissemination and local increase of ACC. In 2004, three hurricanes (Charley, Frances, and Jeanne) and one tropical storm (Ivan) crossed the Florida peninsula and exacerbated preexisting ACC infections and caused overwhelming dispersal of the pathogen over the commercial industry. This resulted in the establishment of numerous new infections at substantial distances from the known pre-existing infections. Storms also intensified the need for survey protocols to detect new foci of infection and subsequent eradication efforts on the part of the CCEP to eliminate new outbreaks. Of great concern to the commercial citrus industry and to the

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regulatory agencies was the determination by National Oceanic and Atmospheric Administration (NOAA) that the annual occurrence of hurricanes and tropical storms has been escalating since 1995 and that the US was experiencing an anticipated 30-yr period of increased Atlantic and Gulf hurricane activity. Because the Florida Citrus industry feared the disease would become uncontrollable, the CCEP needed to detect and eliminate all citrus canker infections in the state prior to additional hurricanes striking Florida and reducing the likelihood that eradication could succeed.

Since then, ACC has greatly increased production costs, and caused loss of fresh fruit markets. The operational basis of the CCEP was a series of science-based regulatory decisions: 1) The 1900-ft law, based on a research study of spread of ACC in over 19,000 trees in south Florida and required removal of all 'exposed trees' within 1900ft (579m) of a diseased tree. 2) The sentinel tree survey, based on the minimal distances of spread that set up a recurring survey within residential areas. 3) Following the hurricanes of 2004, a targeted survey, based on the direction spread of ACC during hurricanes, was used to find and eliminate new infections. 4) Geo-referenced hurricane modeling was used to estimate the spread of ACC from known existing infections due to hurricane Wilma in 2005 that estimated continued eradication would require removal of 169,700ac (68,675ha) of commercial citrus, 25.7% of the remaining industry, an unacceptable amount, and led to the end of the program in 2006.

The GIS models and resulting conclusions also solved a political dilemma by giving the CCEP a compilation of scientifically documented and justified results on which to base the decision to halt eradication. A January 2006, USDA-issued press statement indicated: "USDA Determines Citrus Canker Eradication Not Feasible". The State of Florida immediately reacted by unofficially halting further tree destruction. The situation culminated on May 3, 2006 with the unanimous decision by the Florida House of Representatives to halt the eradication campaign and repeal the 1900-ft eradication statute, officially halting the citrus canker eradication program, ending a tumultuous era in plant pathology and Florida history, and potentially saving the Florida and US taxpayers $100 million/year in continued eradication costs.

While some plant diseases like citrus canker have agro/urban interfaces and socio-economic interactions, others such as chestnut blight, Dutch elm disease, and sudden oak death have natural-land or forest/urban interfaces and interactions. All such interactions require complex assessments to determine if the threshold for eradication has been exceeded and thus eradications should be terminated or if eradication is still feasible and/or socially, politically, and economically desirable. The following issues are presented for further contemplation to aid in this decision making process:

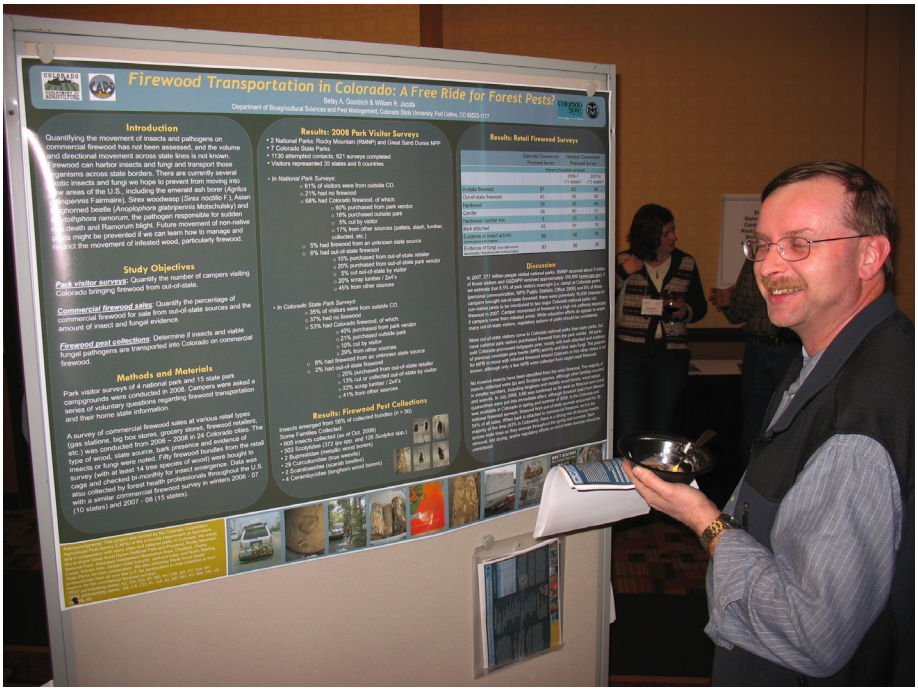
1. Can the culling or removal rate exceed the disease reproductive rate (R_0)?
2. Can you rapidly survey all populations? (the spatial distributions)
- Infected areas to assess eradication progress
- Uninfected areas to rapidly find and extinguish new foci of infection.
3. Are there sufficient resources available?
- Manpower
- Fiscal
- And are deployment logistics feasible considering the spatial distribution(s)
4. Is there sufficient tolerance among all interested groups?
- Regulating agencies
- Government oversight groups
- Commercial stakeholders

  Urban stakeholders (If need cleared areas, i.e., 'firebreaks' to halt spread

Poster Abstracts

Isabel Munck and Lindsey

Stefan Zeglen



Distribution and Impacts of Phellinus Root Disease in the Southern Interior of British Columbia

Michelle Cleary[1] and Rona Sturrock[2]

Phellinus sulphurascens Pilát (syn. *P. weirii*), the causal agent of Laminated root disease (DRL), is a major disturbance agent that occurs throughout most of the range of Douglas-fir in western North America. Little is known about the distribution and impact of DRL in the southern interior of British Columbia (BC), although it is known to often co-occur with Armillaria root disease (DRA). To both implement best management practices and accurately estimate losses to DRL in BC's southern interior, data are needed on its occurrence and incidence. In 2007, landscape level field surveys for root disease were conducted in two BC Ministry of Forests and Range (BCMFR) Timber Supply Areas (TSAs): Okanagan and Kamloops. The sample population consisted of stands occurring in the Interior Cedar Hemlock and Interior Douglas-fir biogeoclimatic zones where Douglas-fir was a leading component and overlapped with BCMFR growth and yield Permanent Sample Plots (PSPs). Stand survey plots consisted of continuous variable width strips 100-m in length, with a total of 5 plots/stand and intersecting as many PSPs as possible. In the Kamloops TSA, DRL was found in 5 of the 24 (21%) stands surveyed; DRA was found in 16 of the 24 (66.6%) stands surveyed. In the Okanagan TSA, DRL was found in 48% (n=27) of the stands surveyed; DRA was found in 85% of surveyed stands. Across both TSAs, between 75 - 89% of the stands surveyed had either DRL or DRA, or both. Armillaria tended to be more homogeneously distributed within stands than DRL. Plot data indicated that in all cases DRA was distributed more widely and comprised a greater percent infection rate than DRL. Work in 2008 – 2010 will include surveys of stand and PSP-level incidence in three additional BC TSAs: Arrow-Boundary, Cascades, and 100 Mile House. Analyses of occurrence and incidence data for DRL (and DRA) and tree growth data associated with sampled PSPs will enable growth and yield specialists to determine Operational Adjustment Factors (OAFs) for Phellinus root disease that can be used in Provincial timber supply determinations.

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Response of *Alnus tenuifolia* to Inoculation with *Valsa melanodiscus*

G.R. Stanosz[1], L.M. Trummer[2], J.K. Rohrs-Richey[3], G.C. Adams[4] and J.J. Worrall[5]

Valsa melanodiscus (anamorph *Cytospora umbrina*) is associated with cankered and killed alder (*Alnus*) stems in western North America from Colorado to Alaska. The responses of thinleaf alder (*A. tenuifolia*) stems to inoculation with each of two isolates of *V. melanodiscus* were studied in south-central Alaska. At each of two sites, eight stems per isolate were wounded to expose both inner bark and sapwood and inoculated in early May 2007 by placing a colonized agar plug over the wound. Sterile agar plugs were applied to wounded control stems. Sunken, elongated cankers similar to those with which *V. melanodiscus* has been associated resulted on inoculated stems. In contrast, wounded control stems exhibited strong callus production and wound closure. In September 2007, cankers were harvested and lengths were recorded. Mean canker lengths measured externally (data for both isolates pooled) at the two sites were 45 (range 20-156) mm and 73 (range 22-201) mm. Analysis of variance of log transformed data revealed strong support for effect of location ($p=0.04$), but not that of isolate ($p=0.12$) or interaction ($p=0.20$) on canker length. The fungus was reisolated from each inoculated stem, but not from any control stem. The ability of *V. melanodiscus* to cause cankers on thinleaf alder stems is confirmed, and these results support the conclusion that this pathogen is a cause of alder dieback in western North America.

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Incidence of Armillaria Root Rot Disease on White Pine Forest in Korea

Eunsung Oh[1] and Bo Young Han[1]

Armillaria species is a facultative pathogen capable of killing trees under favorable condition. It causes root rot and wood decay on deciduous and coniferous species in plantations and forests. *Pinus koraiensis* Siebold et Zuccarini (Korean pine) is a most planted species after the Korean War for restoration of devastated natural forests in Korea. *Armillaria mellea*, *A. tabescens*, *A. ostoyae*, and *A. gallica* have been reported in mixed-conifer forests. In 2007, diseased Korean pines were found in different regions showing resin exudates on the surface of bark up to 2 feet from the soil line. The same symptomatic disease was constantly reported during 2008. When the bark was removed, white mycelia fan was observed as well as rhizomorph on root or in soil. The observation confirmed that the disease was caused by *Armillaria* spp. Also, eastern white pine (*P. strobus*) was highly susceptible. Not all Rhizomorphs were found in Korean pine forests. Mycelium and rhizomorph on diseased pines were placed on MEA added with benomyl and dichloran, and forty-three of isolates were obtained for molecular analysis. Genomic DNAs of the isolates were extracted and amplified IGS regions of ribosomal DNA with O-1/LR12R. The amplified PCR and cloned products were sequenced for identification. Also, PCR products of IGS region were used for RFLP. The results showed that four species of *Armillaria* were responsible for the death of Korean pines by analysis of fragment size and restriction positions: *A. cepistipes*, *A. ostoyae*, *A. tabescens*, and *A. gallica* (E). Also, this is supported by phylogenetic analysis of IGS sequences. The twenty-six isolates were identified as *A. ostoyae* which was 60% of isolates. Eleven isolates of *Armillaria cepistipes* were identified on mostly rhizomorph-based pine forests. A few isolates were *A. gallica* (2 isolates) and *A. tabescens* (1 isolate). This was the first report of presence of *A. cepistipes* on *P. koraiensis* and *A. ostoyae* on *P. strobus* in Korea

Keywords: *Pinus koraiensis, P. strobus, Armillaria,* RFLP

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Longevity of Inoculum Production by *Diplodia pinea* on Red Pine Cones

A. Munck[1] and G.R. Stanosz[1]

Diplodia pinea causes shoot blight, stem cankers, and death of the native red pine (*Pinus resinosa*) in northcentral and northeastern North America. This fungal pathogen sporulates abundantly on mature, open seed cones. In summer of 2004, pycnidia of *D. pinea* were observed on cones that had matured and opened during previous years, but had been retained in canopies of trees at a mature red pine plantation in southern Wisconsin. This observation prompted surveys during the winter and early summer of three consecutive years (2005-2007) to determine incidence and abundance of *D. pinea* conidia on cones of different ages in this stand. During each collection time, cones from three different age classes were collected from the canopy of each of ten trees. Cones from each age class consistently bore pycnidia with conidia of *D. pinea*. A water washing and filtration technique was used to quantify *D. pinea* conidia extracted from colonized cones. Although cones collected in June of the year after their maturation tended to yield more *D. pinea* than older cones, large numbers of conidia were obtained from cones even 3 years after they had matured. Perennial availability of inoculum due to persistence of *D. pinea* on cones of several ages in the overstory or in adjacent stands should be considered when regenerating red pine in areas where this pathogen is known to be present.

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National *Phytophthora ramorum* Early Detection Watershed Surveys 2006-2008

Steve Oak[1], Ed Yockey[1] and Borys Tkacz[2]

The National *Phytophthora ramorum* Early Detection Survey first pilot tested watershed surveys using rhododendron leaf baits in 11 states during 2006 after sustained successful use in OR and CA. Since that date, 320 unique watersheds in 28 states have been surveyed as part of the national survey (table 1).

The pilot survey bore immediate fruit when the pathogen was found in a WA watershed in the first baiting period in 2006, outside of the known disease range in OR and CA. Additional first detections were also made in 2007 in a different WA watershed, and in yet another in MS. In all three cases, the watersheds contained one or more woody ornamental nurseries with confirmed *P. ramorum*. Repeat pathogen detections were made in subsequent years in each watershed, despite the putative absence of infected nursery stock.

Intensive vegetation surveys of stream environs failed to detect any established infection centers, though in MS positive PCR diagnostic results were obtained from symptomatic plant tissue of three different host plant genera collected on two different survey dates during the spring of 2008. Additional baiting and vegetation surveys are planned in the MS watershed for the fall of 2008 and spring of 2009 to detect any established *P. ramorum* infection centers in forest vegetation.

In addition to these new pathogen detections in forest ecosystems outside the disease range, the national survey has contributed to the detection of previously unknown infection centers resulting in the expansion of the disease range in forests within infested counties in OR (Curry) and CA (Mendocino, Humboldt). These are added to the many watersheds in those states found positive by supplemental baiting surveys that are not part of the national survey.

Table 1. Watersheds surveyed under the National *Phytophthora ramorum* Early Detection Survey protocol 2006-2008, by region and year of survey.

	Year				
Region	2006	2007	2008	Total	Unique Watersheds[a]
West Coast	37	32	39	108	75
South	33	64	71	168	137
North Central	0	20	15	35	28
Northeast	24	37	29	90	80
All Regions	94	153	154	401	320

[a] Some watersheds were surveyed in multiple years.

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Evaluating *Neonectria* in Red Alder on State Lands in Western Washington: Extent, Severity, and Associated Ecological Conditions

Amy Ramsey[1] and Daniel Omdal[1]

Stem defects of red alder (*Alnus rubra*) were initially noted in Washington State in 1998 on Weyehaeuser timberlands. The symptoms observed ranged in severity from spot-like bark lesions to severely canker-caused tree mortality. After further investigation, the fungal pathogen *Neonectria major* was found in association with the cankers on the stems and branches of living and recently killed trees, as well as recently thinned slash. This canker fungus is of concern because alder is a keystone nitrogen-fixing species and the value and utilization of red alder continue to increase in the Pacific Northwest.

Thirty trees were examined at each of 45 sites on state lands across western Washington. Soil type, aspect, average stand age, basal area, elevation and biogeoclimatic zone were determined for each site. Crown class, diameter at breast height and canker presence and type were determined for each tree.

There were no site or individual tree variables that significantly explained the presence or absence of cankers. *Neonectria* perithecia were identified on 20% of the sites surveyed, but were only found on 1.5% of the trees. Our results show that *Neonectria* is widely distributed across western Washington and is a rather benign pathogen in naturally regenerated, riparian associated ecosystems. We did not quantify any variables to determine the aggressiveness of *Neoenectria*, but in most cases, the fungus did not appear to discolor the xylem or cause major structural defects. It remains unclear how climate change will affect the virulence of this pathogen on red alder.

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Tree Mortality Caused by Mountain Pine Beetle and Subsequent Fire Occurrence in Colorado

D.R. West[1], J.F. Negron[2], S.L. Costello[3] and W.R. Jacobi[4]

The need for understanding interactions between post-epidemic bark beetle stands and subsequent fire occurrence has escalated due to recent unprecedented mountain pine beetle outbreaks in lodgepole pine dominated forests of Colorado. Historic mountain pine beetle *(Dendroctonus ponderosae* Hopkins) outbreak intensities resulted in widespread tree mortality across Colorado in several forest types. Previous mountain pine beetle-caused mortality was generally thought to increase subsequent fire occurrence but has yet to be supported by research. Our objectives are to determine if a relationship is present between mountain pine beetle outbreaks and subsequent fire occurrence in Colorado; assess the associated weather and fire occurrence in mountain pine beetle outbreak locations of Colorado; and depict the temporal occurrence of those fires since outbreak initiation. We used historic USDA Forest

Service Aerial Detection Survey records dating from 1980 to 1990 in conjunction with USDA Forest Service digital fire location records. Sixty-eight scanned aerial detection maps were utilized in identifying *Dendroctonus ponderosae*-caused mortality over the Arapaho, White River and Uncompahgre National Forests from 1980 through 1990. The combined datasets delineate spatial areas containing lodgepole pine dominated forest type, aerially detected tree mortality from *Dendroctonus ponderosae* (1980-1990) and subsequent historic fire locations. Sixty nine fires were field assessed from June to August 2008 for the Arapaho, White River and Uncompahgre National Forests. The field assessment was conducted to verify the presence of mountain pine beetle-caused mortality prior to the fire as well as to confirm the location of the recorded fire. Due to forest stand conditions and management activities on the Uncompahgre National Forest, we focused our efforts on the Arapaho and White River National Forests in central Colorado. Results from the field assessments are currently under analysis. Further plans include analyzing weather attributes and the temporal relationship associated with the assessed fire events post mountain pine beetle outbreak.

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Special Papers

Fun at the Annual Banquet

Lori gets Pete's vote!!

Twenty-Five Year (1982-2007) History of Lodgepole Pine Dwarf Mistletoe Animal Vectors and Ethephon Control on the Fraser Experimental Forest in Colorado

Thomas Nicholls[1]

Abstract

This is a summary of the 25-year history of studies of mammal and bird vectors of lodgepole pine dwarf mistletoe (Arceuthobium americanum), ethephon control of dwarf mistletoe, and the ecology of the most important dwarf mistletoe vector, the gray jay (Persisoreus canadensis), on the USDA Forest Service, Fraser Experimental Forest (FEF) in Colorado. This paper is dedicated to the memory of the late Dr. Frank Hawksworth who was a plant pathologist and international authority on dwarf mistletoes at the Rocky Mountain Research Station who inspired this study. It is also presented in celebration of the 100th anniversary of the USDA Forest Service Experimental Forests in 2008.

The Fraser Experimental Forest (FEF) Study Area—The 36-sq mile FEF, in the Arapaho National Forest, is located 6 miles southwest of Fraser, in Grand Co. It is administered by the Rocky Mountain Research Station (RMRS) headquartered in Fort Collins, CO. The elevation of the Forest ranges from 8,800 to 12,804 ft.

The USDA Forest Service dedicated the FEF in 1937 as an outdoor laboratory to research sub-alpine forests representative of much of the central and southern Rocky Mountains. In 1978, the Forest was designated a World Biosphere Reserve by the United Nations, one of many worldwide dedicated to the study and conservation of the diversity and integrity of plant and animal communities within natural ecosystems. Forest Service Experimental Forests and Biosphere Reserves, by their nature, are strategic places for carrying out long-term ecological and environmental studies such as reported here.

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Dwarf Mistletoe Studies

Impact of Dwarf Mistletoes—In the western United States dwarf mistletoes have a greater impact on forests than any other pathogen, decreasing growth rates, distorting tree form, reducing wood quality and killing trees. It has been estimated that over 29 million acres are infested in western forests and Alaska with 164 million cubic feet of wood lost annually. Lodgepole pine dwarf mistletoe causes major economic timber production losses through tree deformity and mortality.

Lodgepole Pine Dwarf Mistletoe Animal Vector Study Initiated in 1982—This study was initiated in 1982 when I was a Forest Service Research Plant Pathologist with the North Central Research Station (NCFES), now the Northern Research Station, St. Paul, MN, and by the late Frank Hawksworth (figure 1) of the RMRS, Fort Collins, CO. Over a period of years this study evolved into a series of other studies as new research questions developed during the course of the study.

Animal Vectors of Lodgepole Pine Dwarf Mistletoe Identified—The objective of our study was to identify animal vectors of lodgepole pine dwarf mistletoe and to determine their importance in the establishment of new infection centers that could not be explained by normal spread of sticky mistletoe seeds shot up to 50 feet, or more, by explosive fruits. We used small mammal traps, ear tags, bird mist nets, cell traps, banding, and radio telemetry to document how mistletoe seeds were carried by vectors beyond the normal seed dispersal range of infected trees.

Our study identified ten bird and four mammal vectors of lodgepole pine dwarf mistletoe seed. They included the gray jay, Steller's jay (figure 1), mountain chickadee, dark-eyed junco, hermit thrush, American robin, Yellow-rumped warbler, saw-whet owl, Townsend's solitaire, three-toed woodpecker, least chipmunk, golden-mantled squirrel, red squirrel, and pine marten.

We found that birds and mammals, foraging in infected lodgepole pine, become inadvertent targets of explosive, sticky mistletoe seeds that can stick to feathers or fur. Although such events are rare, a sufficient proportion of birds (27%) carried dwarf mistletoe seeds to make some dispersal probable. As animals move about the forest, or clean their bodies, mistletoe seeds can be deposited on healthy lodgepole pine where they sometimes germinate causing new infections.

Figure 1. Frank Hawksworth and a Steller's Jay in 1982 with a dwarf mistletoe seed on its tail feather, Fraser Experimental Forest, CO.

Silvicultural Control of Small Satellite Pockets of Dwarf Mistletoe Can Reduce Spread—Vector study results explained how new satellite infection centers become established in healthy stands far-removed from main infection centers. Dwarf mistletoe plants are dioecious, so a female and male plant would have to become established within pollination range to develop a satellite infection. Although satellite infection centers are relatively scarce, the explosive mechanism of seed dispersal utilized by dwarf mistletoes enables them to intensify and spread rapidly from a newly established center.

The most practical management plan for controlling new infection centers is to find them through periodic, systematic land or aerial surveys and removing them. This can be done by cutting infected trees and a buffer strip of about two chains of adjacent trees that may be harboring latent infections not yet showing signs and symptoms. Follow-up surveys 5 to 10 years after eradication efforts will determine whether all infected trees were removed.

This management action is recommended to effectively prevent, or slow the spread of dwarf mistletoe from small, isolated infected pockets found in otherwise healthy, merchantable stands.

Chemical Control of Dwarf Mistletoe Using Ethephon Applied by Ground Sprayers Reduced Seed Dispersal up to 4 Years; Helicopter Spray was Ineffective—A chemical control method was tested on the FEF in the 1980s in cooperation with Forest Pathologists David Johnson, USDA Forest Service, Forest Pest Management, Lakewood, CO and Kathy Robbins of NCFES, both now retired. The objective of this work was to determine whether small pockets of infected trees could be saved and adjacent healthy trees protected by treating infected trees with ethephon, a growth regulator. It acts by releasing ethylene, a plant hormone, which is absorbed by the plant and interferes in the growth process. It is found in nature and, among other things, causes tree leaves to abcise at the end of a growing season. We thought it might do the same to mistletoe shoots. It did.

Ethephon at 2,500 ppm in water with a spreader applied by ground sprayers was effective in causing mistletoe shoots, flowers, and fruits to drop off trees (figure 2), thereby, significantly reducing seed dispersal for up to 4 years after treatment. However, it does not kill the parasite's endophytic system in the host tissue, so shoots often re-sprout in 3 to 5 years. As a result, frequent ethephon treatments would be required to effectively manage this disease making it economically unfeasible to use under forest conditions.

Ethephon treatments using ground sprayers can be used to slow the development and spread of dwarf mistletoe in high value trees located in campgrounds, small parks, golf courses, and around buildings.

Presumably, the reduction in dwarf mistletoe shoots can also reduce the drain on the host tree's nutrients from being directed to the parasite. Because of these benefits it was registered with the Environmental Protection Agency for this use.

Figure 2. Lodgepole pine dwarf mistletoe before (left) and several days after (right) being sprayed with ethephon growth regulator on the Fraser Experimental Forest, CO.

Aerial applications of ethephon by helicopter were not effective in controlling lodgepole pine dwarf mistletoe under forest conditions.

Ethephon research results stimulated many other studies of this growth regulator on other dwarf mistletoe species achieving similar results.

Dwarf Mistletoe Benefits Wildlife—Later, looking though the eyes of a wildlife biologist rather than those of a forest pathologist, having switched disciplines in 1986, I found that control of dwarf mistletoe may not be the best management action to take in all situations, especially in terms of overall ecosystem health and diversity.

While dwarf mistletoes are a major cause of tree deformity and mortality in affected coniferous stands throughout the northern hemisphere causing significant economic damage, the resulting dead and declining trees have a positive affect on many wildlife species who use the trees for nesting, shelter and food in insects attracted to such trees.

Mistletoes create canopy openings providing conditions suitable for plant species not ordinarily found in dense, healthy stands which in turn attract a variety of animal species. Mistletoe shoots are eaten by some mammal and bird species. Insects are abundant in affected trees attracting a wide variety of insect eating birds such as woodpeckers, nuthatches, and warblers as we saw on the FEF. In addition, there are several species of raptors and songbirds that nest in witches' brooms of various dwarf mistletoe species.

Based upon the FEF study and related studies, mistletoes have been found to play a positive role in creating more compositional (both plant and animal), structural, and functional diversity in the forest. Whether this is good or bad depends upon the management objectives for any given forest stand. For example, if timber management for forest products is a primary objective, dwarf mistletoe control is essential when economically feasible. If wildlife management, species diversity, and wildlife viewing are the primary objectives, control may not be essential and may even be detrimental to some wildlife, especially in marginal or non-commercial stands.

Gray Jay Studies

Early study results found that the gray jay is one of the most important vectors of lodgepole pine dwarf mistletoe on the FEF. As a result, later work began to focus on gray jay movements, longevity, health, site fidelity, and vector ecology to better understand this species. During the course of these later studies, it became clear that the gray jay, a year-round resident of the Forest, is an integral part of the ecosystem,

maybe even a keystone species. This species is a remarkable, highly intelligent, long-lived, territorial bird with amazing survival tactics and communication skills.

I found the ecology of the gray jay so interesting in its own right that I continued research on this species as a Forest Service Volunteer since my retirement in 1994 as has my wife, Mary Lou, also a Forest Service Volunteer.

With the help of NCFES Biological Technician Leanne Egeland, now with the USDA Forest Service Forest Health Management Unit, Gunnison, CO, we have studied gray jays on the FEF for 25 consecutive years starting in 1982. This study is believed to be the longest continuous study of gray jays in the United States.

Figure 3. Manuel Martinez with a 17-year-old gray jay on the Fraser Experimental Forest, CO, the oldest gray jay recorded in the United States according to the USGS Bird Banding Laboratory.

Banding Reveals Long-lived, Territorial Gray Jays — We banded and released 668 individual gray jays on the FEF over the 25 years. We used over 40 mist-net trapping locations to capture birds, each located about ½ mile apart centered on the FEF Headquarters. The average weight of these birds was 73 grams, average wing length 153 mm and average tail length 142 mm.

We handled a total of 1,891 new and retrapped gray jays over the 25 years of our study. Many were retrapped and released many times, often at the same location, or at a nearby location, where they were originally banded. These results showed adult birds are highly site specific and territorial.

Fifty-seven of the banded gray jays achieved long-lived status of between 8 and 17 years of age (table 1). In fact, FEF has the distinction of having had the oldest recorded living gray jay in the wild. It was recaptured on 30 Aug 2002, 17 years after it was originally banded on 16 Aug 1985 (figure 3). This is a U.S. record for gray jay longevity according to the USGS Bird Banding Laboratory.

The record gray jay was originally banded at the FEF Headquarters as a hatch-year bird on 16 Aug 1985. It dispersed about 2 miles away and was retrapped and released on its new territory on 8 Sept 1998, 10 Sept 1999, 8 Sept 2000 and was last caught on 30 Aug 2002. The bird's weight remained normal over the years ranging between 69 and 73 grams.

Table 1. Minimum age class of 668 individual gray jays trapped, banded, and released on the Fraser Experimental Forest, Grand Co., CO from 1982 to 2007.

Minimum Age	No. Individuals
0 (Hatch Year)	203
1	212
2	72
3	34
4	24
5	28
6	18
7	20
8	22
9	11
10	8
11	6
12	6
13	0
14	1
15	2
16	0
17	1
Grand Total	668 Gray Jays

Gray Jays Year-round Residents on the FEF—Study results revealed a relatively long life span and high site fidelity for resident adult gray jays that live in permanent all-purpose territories in the sub-alpine forests where they live under extreme winter weather conditions at high elevations of around 9,000 to 11,000 feet. The bird survives these harsh conditions because it has a rather unique way of preserving food.

Gray jays possess two large mandibular salivary glands, one on each side near the base of the bill. The jay shapes its food into an oval pellet, or bolus, with its tongue and permeates it with saliva. The sticky saliva is used to glue food pellets to vegetation during the non-winter months where they dry to form a hard protective covering around the food. What's more remarkable, gray jays can remember where they store most of their food enabling them to survive the long, harsh winters on the FEF.

FEF Home to an Estimated 682 Gray Jays—In 2005, 39 gray jays on the FEF were color-banded by Jennifer Berg (now Jennifer Lansing), an MS student at the University of Colorado—Denver under the direction of Professor Diana Tomback, and followed to determine habitat use. The purpose of the study was to create a method to predict carrying capacities for birds by using Geographic Information System techniques by using our available information on gray jay distribution, habitat use, and territorial sizes. Based upon this work, Berg (Lansing) and Tomback estimated there is a population of about 682 gray jays on the 36-sq mile FEF.

Polymerase Chain Reaction (PCR) Technique used to Sex Gray Jays for the First Time—The plumage of female and male gray jays is identical, so we were unable to sex the birds in the field. For the first time in 2005, blood samples were used to identify the sex of gray jays using PCR. Avian sexing PCR uses the fact that male and female birds have different genes or chromosomes, much like mammals.

So far, we have been able to determine the sex of 74 gray jays, 38 males and 36 females. As a control, the PCR method was used to correctly sex four red-shafted flickers and one hairy woodpecker that can also be sexed by plumage in the field.

As this data base develops, it can serve as a basis for studying genetic parentage, relationships, and dispersal of related gray jays on the FEF.

Introduced West Nile Virus (WNV) Threatens Gray Jays in 2003 —An outbreak of the introduced mosquito-borne WNV in 2003 posed a threat to the gray jay population on the FEF as well as to humans throughout Colorado. More humans (2947) were infected in Colorado in 2003 than any other state and 63 of those people died.

Zoonotic pathologist Kurt Reed M.D. of the Marshfield Clinic Research Foundation (MCRF) now Professor of Pathology, Northwestern University School of Medicine joined our research team in 2003 to study the impact of WNV on gray jays. He took blood samples from 296 gray jays from 2003 to 2007. We do not as yet have the results of 60 samples taken in 2007. The other 236 blood samples tested negative for WNV antibodies except for two gray jays (band nos. 9822-51941 and 9822-52036) that tested positive with high WNV antibody titers of @1:20 and @1:40, respectively.

Jays are highly susceptible to the virus and many individuals may have died before they could develop protective antibodies and before we could find them in the field where they can be quickly picked up by scavengers. However, circumstantial evidence as follows showed a major decline in the jay population that we hypothesized was caused by WNV.

The population of gray jays on the FEF had been healthy for at least 21 years, but something was different about the birds in 2003. They were more difficult to trap and far fewer birds were trapped than in the previous 4 years despite similar trapping effort. There was a 37% decrease in the number of birds netted in 2003 (N=74) compared to 2002 (N=117). There was an overall 33% decline in the capture rate over the previous 4 years, 1999 to 2002, compared to 2003. We are not sure whether WNV mortality was the cause of this decline, but our WNV blood test results hinted that WNV might have been the cause. As WNV waned in CO after 2003, the gray jay population on the FEF rebounded in 2005 and 2006 by 16% and 22%, respectively.

WNV outbreaks, like other arboviruses, are cyclical in nature. We might be able to further strengthen our hypothesis that WNV was the cause of the population decline by making observations during the next WNV outbreak in Colorado. If and when that will happen is an unknown, but that is why long-term studies are so valuable for ecological research.

Mountain Pine Beetle (Dendroctonus ponderosae) Outbreak Threatens Gray Jay Habitat in 2007 and Kills Mistletoe-infected Lodgepole Pine—Without normally cold recent winters to kill off their larvae and sustained drought to predispose the trees to attack, native mountain pine beetles had infested up to 90 percent of older lodgepole pine stands in Colorado by 2007. Recent aerial surveys reveal that dead and dying lodgepole acreage has grown to 1.5 million in Colorado since the first signs of outbreak in 1996.

The beetle threatens esthetics of recreational areas and valuable home sites, forest products, watersheds, and wildlife habitat for some species, but a boon for others like woodpeckers. The drying dead trees present a serious fire risk.

Until fire control was initiated about 100 years ago, fire was a natural control of dwarf mistletoes. It appears that the recent mountain pine beetle tree mortality is having a similar natural control affect in that it is killing thousands of mistletoe-infected trees, trees that otherwise would intensify the spread of dwarf mistletoe.

By 2007, the pine beetle outbreak had killed thousands of older lodgepole pine in prime gray jay habitat on the FEF. The impact of this significant tree mortality on gray habitat and populations, as well as on other wildlife, is yet to be determined—a major reason to continue this long-term study on the FEF.

When we initiated this study in 1982, we thought for sure that dwarf mistletoe was the worst possible pest threat to lodgepole pine and that it warranted significant research and control. So 25 years later, it now begs the question which pest, dwarf mistletoe or mountain pine beetle, is more important to the health of lodgepole pine, the forest, and to the ecosystem in the long run? Only long-term research can answer this question—one more reason to make sure our Forest Service Experimental Forests are preserved for long-term studies.

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Study Publications

The following papers, listed in chronological order, have been published based on information gathered in all, or in part, during the FEF study. In addition to these publications, numerous progress reports were issued over the past 25 years.

Nicholls, T.H., Hawksworth, F.G. 1983. Animal vectors of lodgepole pine dwarf mistletoe. Abstract ASSI. Phytopatholgy 73(5):836.

Nicholls, T. H., Hawksworth, F.G., Merrill, L.M. 1984. Animal vectors of dwarf mistletoe, with special reference to *Aceuthobium americanum* on lodgepole pine. In: Hawksworth, F. G., Scharpf, R.F., eds. Biology of dwarf mistletoes: Proceedings of the symposium; 1984 August 8; Fort Collins, CO. General Technical Report RM-111. Fort Collins, CO: USDA, Forest Service, Rocky Mountain Forest and Range Experiment Station: 102-110.

Nicholls, T.H., Hawksworth, F.G., Merrill, L.M. 1984. A preliminary look at animal vectors of lodgepole pine dwarf mistletoe. In: Dubreuil, Suzanne H., comp. Proceedings 31st Western International Forest Disease Work Conference; 1983 August 22-26; Coeur d'Alene, ID. Missoula, MT. USDA, Forest Service, Northern Region: 54-56.

Nicholls, T.H., Hawksworth, F.G., Egeland, L. 1987. Animal vectors of *Arceuthobium americanum* on lodgepole pine. In: Cooley, S. J., comp. Proceedings, 34th Annual Western International Forest Disease Work Conference; 1986 September 8-12; Juneau, AK. Portland, OR: USDA Forest Service, Forest Pest Management: 48-50.

Nicholls, T.H., Egeland, L., Hawksworth, F.G., Johnson, D.W. 1987. Control of dwarf mistletoe with ethephon. In: Cooley, S. J., comp. Proceedings, 34th Annual Western International Forest Disease Work Conference; 1986 September 8-12; Juneau, AK. Portland, OR: USDA, Forest Service, Forest Pest Management: 78-85.

Nicholls, T.H., Egeland, L., Hawksworth, F.G., Johnson, D.W., Robbins, M.K. 1987. Control of dwarf mistletoes with a plant growth regulator. In: Troendle, C.A., Kaufmann, M.R., Hamre, R.H., Winokur, R.P., eds. Management of subalpine forests: building on 50 years of research: Proceedings of a technical conference; 1987 July 6- 9; Silver Creek, CO. General Technical Report RM-149. Fort Collins, CO: USDA, Forest Service, Rocky Mountain Forest and Range Experiment Station: 154-156.

Hawksworth, F.G., Nicholls, T.H., Merrill, L.M. 1987. Long-distance dispersal of lodgepole pine dwarf mistletoe in: Troendle, C.A., Kaufmann, M.R., Hamre, R.H., Winokur, R.P., eds. Management of subalpine forests: building on 50 years of research: Proceedings of a technical conference; 1987 July 6-9; Silver Creek, CO. General Technical Report RM-149. Fort Collins, CO: USDA Forest Service Rocky Mountain Forest and Range Experiment Station: 220-226.

Hawksworth, F.G., Johnson, D.W. 1989. Biology and management of dwarf mistletoe in lodgepole pine in the Rocky Mountains. General Technical Report RM-169. Fort Collins, CO: USDA, Forest Service, Rocky Mountain Forest and Range Experiment Station. 38 p.

Nicholls, T.H. 1989. Ethephon tests for control of lodgepole pine dwarf mistletoe in Colorado. In: van der Kamp, Ban J., comp. Proceedings of the 36th Western International Forest Disease Work Conference; 1988 September 19-23; Park City, UT. Vancouver, Canada: Dept. of Forest Science, University of British Columbia. 34-37.

Nicholls, T.H., Egeland, L., Hawksworth, F.G. 1989. Birds of the Fraser Experimental Forest, Colorado, and their role in dispersing lodgepole pine dwarf mistletoe. Colorado Field Ornithologists 23: 3-12.

Robbins, K., Johnson, D.W., Hawksworth, F.G., Nicholls, T.H. 1989. Aerial application of ethephon is ineffective in controlling lodgepole pine dwarf mistletoe. Western Journal of Applied Forestry 4(l):27-28.

Ostry, M.E., Nicholls, T.H. 1991.The forest beyond the trees: beneficial roles of disease in forest health. In: Proceedings of the 1997 Society of American Foresters National Convention, Meeting in the Middle, 1997 October 4-8; Memphis, TN. 167- 172.

Hawksworth, F.G., Weins, D. 1996. Dwarf mistletoes: biology, pathology, and systematics. Agricu. Handb. 709. Chapter 8: 73-89. Washington, DC: USDA, Forest Service. 410 p.

Berg, Jennifer. 2006. Estimating population sizes of the gray jay (*Perisoreus canadensis*) using geographic information systems and habitat preferences. M.S. thesis, University of Colorado—Denver. 69 p.

Comparison of Two Dwarf Mistletoe Rating Systems for Infected Douglas-fir

Katy M. Mallams[1]

Background

In 1992 ten permanent plots were established in Douglas-fir dwarf mistletoe-infected stands in the southern Oregon Cascade Mountains on the Rogue River and Umpqua National Forests. One objective of the project was to validate the dwarf mistletoe extension in the Forest Vegetation Simulator (FVS) model (Wykoff et al 1982). This extension modifies projections of tree growth and mortality to account for the effects of dwarf mistletoe infection. In FVS, Douglas-fir dwarf mistletoe is quantified using the 6-class dwarf mistletoe rating (DMR) system (Hawksworth 1977). This system is based on the proportion of branches infected in each third of the live crown. It works best in host species with open crowns and dwarf mistletoes that form no brooms or small, open brooms so that tree boles, branches and mistletoe infections are visible from the ground. Douglas-fir dwarf mistletoe-infected trees can be very difficult to rate using this system because Douglas-fir dwarf mistletoe often forms very large, dense, complex brooms that obscure much of the bole and branches, particularly in tall trees. To cope with this difficulty, Tinnin (1998) developed the Broom Volume Rating System (BVR). BVR is based on the volume of each live crown third occupied by brooms. This system was used to quantify the level of Douglas-fir dwarf mistletoe infection in the ten permanent plots.

After the ten year remeasurement of the plots, the data were used to test the dwarf mistletoe extension. FVS was run for one ten year cycle using the data from 1992 and the results compared to the data from 2002.

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The rate of diameter growth and mortality in the plots after ten years was also compared to the rates in the Dwarf Mistletoe Impact Modeling (DMIM) system that modifies FVS to account for dwarf mistletoe (David 2005). Although sampling by Tinnin (1998) showed that rating Douglas-fir dwarf mistletoe with the DMR and BVR systems gave very similar results, there was concern that differences that were observed in growth and mortality between the plots and the FVS output and DMIM might have been due to the use of different rating systems. To resolve this concern, infected Douglas-firs in a subsample of plots were rated using the DMR system and the results compared to the BVR rating given in 2007, during the fifteen year remeasurement of the plots (Mallams 2008).

Methods

Three of the ten plots were visited in July 2008. A total of 62 infected Douglas-firs were re-rated using the DMR system. The ratings were done by the same person who rated the mistletoe using BVR in 2007. While rating the mistletoe with the DMR system they did not look at the previous BVR ratings. After the ratings were completed, average DMR for each crown third was calculated and compared to the BVR using Microsoft Office 2000 Excel for Windows.

Results and Discussion

Forty of the 62 Douglas-firs (65 percent) received the same rating with both systems (Table 1). Among the 22 trees that received different ratings, nine (41 percent) were rated higher with BVR, and 13 (59 percent) were rated higher with DMR. The average rating for all 62 trees was 3.2 using DMR and 3.1 using BVR (Table 2).

Of nine trees with total BVR higher than DMR, the difference was due to higher BVR in the middle crown third of six trees. Many of the large Douglas-firs had many branches in the middle crown third.

Although dwarf mistletoe was abundant in these trees, the brooms originated on less than half the branches, resulting in higher BVR than DMR. However, DMR was higher than BVR in trees where there was only one branch in the bottom crown third and it had a broom. This resulted in a DMR of 2 for those crown thirds regardless of the size of the broom. It was difficult to determine how many branches there were in the middle and upper crown thirds of large Douglas-fir with large dense brooms, and which crown third the infected branches originated from. This would have affected the DMR that was given but not the BVR.

Table 1. Comparison of rating systems by number of trees (n = 62).

	BVR							
	Class	1	2	3	4	5	6	Total
DMR	1	6	2					8
	2	4	12	2				18
	3		3	6	3			12
	4			2	7	2		11
	5				1	5		6
	6			1[1]		2	4	7
Total		10	17	11	11	9	4	62

[1.] A portion of the top of this tree broke off between ratings

Conclusion

Although there were differences in individual tree ratings using the two systems, the overall difference in a large sample of infected trees was very small. Such a small difference would not have affected the comparison of the permanent plot data with DMIM or FVS model outputs. BVR was easier to visualize and faster to use, particularly in large Douglas-fir with large, dense, complex brooms where individual branches are very difficult to see.

Table 2. Average ratings by crown third, infected trees (n = 62).

	Bottom third	Middle third	Upper third	Total
DMR	1.8	1.0	0.4	3.2
BVR	1.7	1.1	0.3	3.1

Literature Cited

David, L.e R. 2005. Dwarf mistletoe impact modeling system: User guide and reference manual nonspatial model: 2005 update. USDA Forest Service, Forest Health protection, Forest Health Technology Enterprise Team. Fort Collins, CO. Unpublished report. October 2005. 73 p.

Hawksworth, F.G. 1977. The 6-class dwarf mistletoe rating system. General Technical Report RM-48. USDA Forest Service Rocky Mountain Forest and Range Experiment Station, Fort Collins, CO. 7 p.

Mallams, K.M. 2007. Permanent plots for measuring spread and impact of Douglas-fir dwarf mistletoe in the southern Oregon Cascades, Pacific Northwest Region: Results of the ten year remeasurement. USDA Forest Service Pacific Northwest Region Southwest Oregon Forest Insect and Disease Service Center, Central Point, OR. SWOFIDSC-07-04. 34 p.

Mallams, K.M. 2008. Permanent plots for measuring spread and impact of Douglas-fir dwarf mistletoe in the southern Oregon Cascades, Pacific Northwest Region: Results of plot remeasurement 2002-2007. USDA Forest Service Pacific Northwest Region Southwest Oregon Forest Insect and Disease Service Center, Central Point, OR. SWOFIDSC-08-01. 6 p.

Tinnin, R.O. 1998. An alternative to the 6-class dwarf mistletoe rating system. Western Journal of Applied Forestry 13(2): 64-65.

Wykoff, W.R., Crookston, N.L., Stage, A.R. 1982. User's guide to the stand Prognosis model. General Technical Report INT-133. USDA Forest Service Intermountain Forest and Range Experiment Station, Ogden, UT. 112 p.

Inoculation of Whitebark Pine Seedlings with Native Mycorrhizal Fungi: Preliminary Screening Results

C.L. Cripps[1]

Abstract

Whitebark pine (*Pinus albicaulis* Engelm.) forests are in serious decline due to blister rust, mountain pine beetles, fire suppression and possibly climate change. In some areas of the western U.S. forests have declined over 90% or have been totally decimated. These pines form forests at tree-line and are important in watershed dynamics, as early colonizers and keystone species that provide habitat, and as a critical food source (pine nuts) for grizzly bears where ranges overlap. Restoration efforts to save these forests have increased dramatically over the last two decades and now include the planting of nursery grown rust resistant seedlings in openings and burned areas. Over 200,000 nursery seedlings have been planted in the western U.S but survival rates are low in many areas. One neglected area of research is the application of mycorrhizal fungi to nursery seedlings before out-planting to enhance seedling survival. For this study, 26 strains of native ectomycorrhizal fungi were isolated from whitebark pine forests in the Greater Yellowstone Ecosystem and screened for their potential as inoculum for whitebark pine seedlings. A majority of the strains tested were suiloid fungi, known to be specific for pines and in this case 5-needle or stone pines. Of the 26 isolates examined (16 as cultures, 10 as spore slurries), six grew well enough to be developed into a liquid and/or a soil inoculum. This includes three native strains of *Suillus,* one of *Rhizopogon,* plus *Cenococcum geophilum*. These strains were inoculated onto whitebark pines seedlings; these will be assessed for effective mycorrhization at a future date. Commercial inocula should not be used in sensitive whitebark pine systems and it is therefore important to identify native fungi that can be used in the nursery when inoculation is deemed necessary.

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Introduction

Whitebark pine (*Pinus albicaulis* Engelm.) forests are in serious decline due to blister rust, mountain pine beetles, fire suppression and possibly climate change (Schwandt 2006). In some areas of the western U.S. forests have declined 90% or more. Restoration efforts have been ongoing for over 15 years (Tomback et al. 2001) and include development of seed germination methods (Burr etal. 2001), nursery production of whitebark pine seedlings (Burr et al. 2001), selection of rust resistant strains (Mahalovich and Dickerson 2004), research on seedling diseases (Dumroese 2008), and use of burned sites for out-plantings (Keane and Arno 2001). Over 200,000 nursery seedlings have been planted in the western U.S and survival rates are low in many areas (Izlar 2007). One neglected area of research is the application of mycorrhizal fungi to nursery seedlings before out-planting to enhance seedling survival.

All pines, including whitebark pine, need ectomycorrhizal fungi to survive in nature (Smith & Read 1997). These fungi enhance survival by providing nutritional benefits, imparting drought tolerance and offering protection from pathogens & soil grazers (Cripps 2002, 2004). In nature, non-mycorrhizal seedlings are at risk when planted in soil lacking appropriate mycorrhizal fungi. Therefore the presence of appropriate mycorrhizal fungi must be a major consideration for evaluating seedling performance (monitoring) and in silviculture methods for mycorrhizal inoculation of nursery pines (Landis et al. 1990). The USFS handbook recommends that mycorrhizal techniques be tested on a small scale before trying to inoculate an entire nursery. Greenhouse methods for fungal inoculation vary in success and need to be developed for *each* tree species (Landis et al. 1990). Methods for inoculation of whitebark pine should include the use of appropriate native mycorrhizal fungi and those important to whitebark pine survival in nature (Mohatt et al. 2008).

Ectomycorrhizal fungi are difficult to find fruiting in whitebark pine forests at tree-line. However, over 40 species of ectomycorrhizal fungi have been confirmed with whitebark pine on our sites in the Greater Yellowstone Ecosystem which contain some of the last remaining intact forests (Cripps & Mohatt 2005, Mohatt 2006, Cripps et al. 2008, Mohatt et al. 2008). Many of these are suilloid fungi that are host-specific on some level (Bruns et al. 2002). Individual species are restricted to pine, 5-needle pine, or stone pine. The suilloids (*Suillus, Rhizopogon*) are also of interest because this group is known to be important in the establishment of pine seedlings and they have been successfully used in nurseries to this effect (Steinfeld et al. 2003). In Austria, stone pines have been inoculated for over 50 years with native suiloid fungi which has dramatically increased the out-planting success rate at high elevations (Moser 1956, Weisleitner, pers. comm. 2008).

The main goal of this project is to develop methods for inoculation of whitebark pine seedlings with native ectomycorrhizal fungi under nursery conditions. We have made significant progress in capturing native fungi from whitebark pine forests in the GYE for this project. Objectives are to 1) evaluate native fungi collected from whitebark pine forests for their potential as inoculum and 2) compare inoculation methods for efficiency of mycorrhizal colonization. Progress on the screening procedure for ectomycorrhizal fungi (objective 1) is presented in this paper. Results are not yet available for objective 2 as tests are still ongoing.

Methods

Ectomycorrhizal fungi were collected from whitebark pine forests in the Greater Yellowstone Ecosystem and ecological parameters recorded. Details of locations are in the MSU database of fungal collections (MONT Herbarium). Fungi as sporocarps (mushrooms/truffles) were identified using classical taxonomic methods and as ectomycorrhizae on roots using molecular techniques (DNA extraction, PCR, sequencing ITS region and BLAST search or comparison to our own DNA library) (Mohatt et al. 2006). Tissue was removed from sporocarps using sterile technique and plated out on Petri dishes of Modified Melin Norkrans (Brundrett et al. 1996). Ectomycorrhizae were surface sterilized with hydrogen peroxide or 10% Clorox solution and plated out on MMN (figure 1). The presence or absence of growth *in vitro* was used as an initial screening for fungi potentially useful in inoculum development. Pure cultures which survived and grew were transferred to liquid MMN media and then soil media (peat: vermiculite, 1:9 v/v, plus MMN) for further testing. In some cases, mature fruiting bodies, particularly of hypogeous fungi were ground into spore slurries in de-ionized water and used for direct inoculation of seedlings. The ability of each ectomycorrhizal fungus to grow in the various media types (plate, liquid, and soil) was assessed. Those showing vigorous growth were selected for inoculation of whitebark pine seedlings under various conditions in the greenhouse.

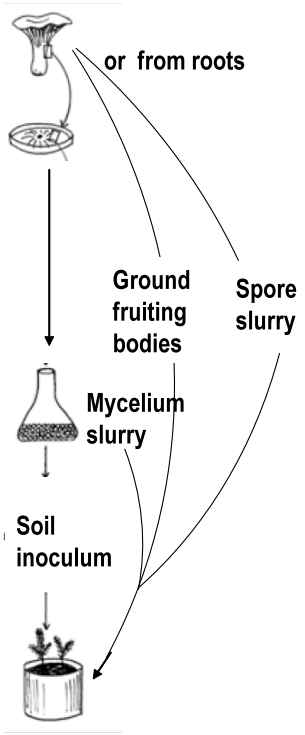

Figure 1. Flow chart for inoculation of native ectomycorrhizal fungi onto whitebark pine seedlings.

For objective 2 (results not reported here as tests are ongoing) approximately 300 rust-resistant whitebark pine seedlings from the Forest Nursery in Coeur D'Alene were inoculated with selected fungi. These consisted of five species of suilloids that grew vigorously in culture and 10 fungi (mostly suilloids) that were over mature and ground into spore slurries. Treatments of N=10 each were set up to test various inoculation methods, timing of inoculation (age of seedlings),

and fertilization regimes for the most efficient colonization (Rincon et al. 2005). Seedlings are maintained in the Plant Growth Center at Montana State University. Assessments of mycorrhizal colonization of roots systems will determine the most effective treatments.

Results

A total of 26 native ectomycorrhizal fungi were collected for initial screening primarily from whitebark pine forests in the Greater Yellowstone Ecosystem, and most were suilloid fungi (table 1). *Cortinarius, Hygrophorus, Lactarius* and *Russula* species were not considered for testing since it is known that these genera do not grow *in vitro* and are primarily associated with mature trees and not seedlings. *Laccaria* and *Hebeloma* species, typically used as fungal inoculum, have not yet been confirmed with whitebark pine seedlings. All sixteen of the collections tissue cultured (primarily from sporocarps) onto Petri "plates" grew *in vitro* on MMN media (M=growth, column 6). Six showed vigorous growth and were selected for further testing with seedlings i.e. CLC 2241 *Suillus subalpinus* M.M. Moser, CLC 2244 *S. variegatus* (Sw.) Kuntze, CLC 2245 *S. sibiricus* (Singer) Singer, CLC 2199 *Suillus sp*., CLC 2294 *Rhizopogon subbadius* A.H. Smith, VT *Cenococcum geophilum* Fr. These six were then tested for their ability to grow in "liquid" MMN culture and peat:vermiculite "soil" (table 1, columns 7 & 8). All six were able to grow in both of these substrates and were used as liquid or soil inoculum to inoculate seedlings (table 1, column 9). Seedlings are currently maintained in the greenhouse awaiting analysis for mycorrhizal colonization. An additional eight fungi were ground into spore slurries (S, column 6) and added directly to seedlings; these were primarily over-ripe suilloid fungi not suitable for tissue culturing. All slurries were then added to the seedlings currently maintained in the greenhouse awaiting analysis for mycorrhizal colonization. The slurries are also being incubated to test shelf life.

Table 1. Screening of native ectomycorrhizal fungi from whitebark pine forests for potential use as inoculum for rust-resistant seedlings as assessed by growth characteristics on various substrates.

No.	Mycorrhizal species	Location	Source	Host	Plate[a]	Liquid[b]	Soil[c]	Seedling[d]
CLC 2035	Rhizopogon subpurp.	New World	sporocarp	P. albicaulis	M			
CLC 2036	R. sp	New World	sporocarp	P. albicaulis	M			
WO 81.1	Tricholoma moseri	New World	sporocarp	P. albicaulis	M -			
Rhiz 1w	R. cf ochraceorubens	Waterton Park	sporocarp	P. contorta	M			
Hyp 1	R. cf salebrosus	Waterton Park	sporocarp	P. flexilis	M			
GDP 1	R. sp.	Glacier Park	roots	P. flexilis	M			
UB 7	R. sp (Ben)	Fridley Burn	native soil	P. albicaulis	M			
CLC 2199	Suillus sp. (veil)	Yellowstone	sporocarp	P. albicaulis	M+	+	+	+
CLC 2294	R. subbadius	Yellowstone	sporocarp	P. flexilis	M+	+	+	+
CLC 2241	S. subalpinus	New World	sporocarp	P. albicaulis	M+	+	+	+
CLC 2244	S. variegatus	New World	sporocarp	P. albicaulis	M+	+	+	+
CLC 2245a	S. sibiricus (thick)	Yellowstone	sporocarp	P. albicaulis	M +	+	+	+
CLC 2245b	S. sibiricus (thin)	New World	sporocarp	P. albicaulis	M			
CLC 2246	S. cf. brevipes	Yellowstone	sporocarp	conifers	M -			
CLC 2247c	S. subalpinus	Yellowstone	sporocarp	P. albicaulis	M			
VT	Cenococcum geophil.	Eastern US	roots	conifer	M +	+	+	+
CLC 2275	S. sibiricus	Beartooths	sporocarp	P. albicaulis	S			+
CLC 2277	R. subpurpurascens	Beartooths	sporocarp	P. albicaulis	S			+
CLC 2279	R. cf evadens R 1	Yellowstone	sporocarp	P. albicaulis	S			+
CLC 2280a	R. cf molligleba R2	Yellowstone	sporocarp	P. albicaulis	S			+
CLC 2280b	R. sp. (yellow) R3	Yellowstone	sporocarps	P. albicaulis	S			+
CLC 2281a	R. olivaceofuscus 4,5	New World	sporocarp	P. albicaulis	S			+
CLC 2282	Thaxterogaster sp.	New World	sporocarp	P. albicaulis	S			+
NW hyp 1	Hypogeous 1	New World	sporocarp	P. albicaulis	S?			
NW Hyp 2	Hypogeous 2	New World	sporocarp	P. albicaulis	S?			
XX07	Rhizopogon sp	Yellowstone	grizzly scat	P. albicaulis	S			+

[a] growth on Petri 'plates' of MMN (M = growth).
[b] growth in 'liquid' MMN media (+ = growth).
[c] growth in peat:vermiculite (1:9 v/v) 'soil' mix (+ = growth).
[d] fungi used to inoculate whitebark pine seedlings.

Discussion

Over 40 species of native ectomycorrhizal fungi are known to associate with whitebark pine in the Greater Yellowstone Ecosystem (Mohatt et al. 2008) and on burns (Trusty and Cripps 2007). Suilloid fungi (*Suillus, Rhizopogon*) comprise a significant portion of these in unburned forests. This appears to be a rather limited set of mycorrhizal fungi and many of these are suilloid species that show specificity for 5-needle pines or stone pines. Therefore spruce, fir or other pine species cannot be a reservoir for these host-restricted fungi. As whitebark pine forests decline, these fungi may be lost in areas where replanting is necessary or may already be gone from forest soils where succession has advanced or soils have remained without living whitebark pine for several years (Wiensczyk et al. 2002). Therefore it is important to catalog and capture the relevant suilloids for whitebark pine before forests decline since they are known to be important in pine seedling regeneration. It may be necessary to inoculate nursery seedlings destined for sites where appropriate native mycorrhizae are lacking.

Of the *Suillus* species isolated, *Suillus variegatus* and *S. sibiricus* are known to be specific for 5-needle pines with a preference for stone pines, and *S. subalpinus* is a local endemic specific for whitebark pine. *Suillus variegatus* and *S. sibiricus* also occur with stone pines in Europe and Asia (Moser 2004) and with western white pine (*Pinus monticola*) in North America suggesting a long co-evoutionary history (Wu et al. 2000). While many *Rhizopogon* species are suspected of a preference for 5-needle species of pine, this is not yet confirmed for our isolates of *R. evadens* A.H. Smith, *R. molligleba* A.H. Smith, *R. olivaceofuscus* A.H. Smith, *R. c.f. ochraceorubens* A.H. Smith, *R. salebrosus* A.H. Smith, *R. subbadius* A.H. Smith, *R. subpurpurascens* A.H. Smith and *unknown species*. However, several of these species have been found repeatedly with whitebark pine in the GYE, Glacier-Waterton Lakes National Parks and other areas of southwestern Montana. The importance of the suiloid fungi for whitebark pine sustainability is not yet known. Other ectomycorrhizal fungi from these forests such as *Cortinarius, Hygrophorus, Lactarius* and *Russula* species may be specific for the pines but appear to associate mainly with mature trees. More generalist fungi such as *Amphinema, Cenococcum, Piloderma* and *Pseudotomentella* occur on whitebark pine seedlings, but may also associate with a variety of conifer seedlings and inoculation with these might not give whitebark pine a competitive edge. These are not typically grown as inoculum for seedlings in nurseries.

Figure 2. Suilloid ectomycorrhizae on an inoculated European stone pine (*Pinus cembra*), Federal Nursery, Innsbruck, Austria. Photo by D. Bachman.

Although substrate formulation could likely be improved for faster growth, most of the whitebark pine suilloids tested grow *in vitro*. The three *Suillus* and one *Rhizopogon* species that exhibit the most vigorous growth are common in whitebark pine forests and may prove important in its restoration. Several methods of inoculum development are possible each with its own advantages and drawbacks. Development of a liquid inoculum, while easy, is amenable to contamination problems and can result in delayed mycorrhizal colonization. Soil inoculum takes time to develop but may be more amenable to commercial use in the nursery. All six fungi tested were able to grow in both liquid and soil media suggesting either is a viable option. Soil slurries can result in quick mycorrhization under the correct nursery conditions, but rely on fresh mature fruiting bodies as a source at the time of inoculation unless storage methods for spores can be developed. Shelf life tests will determine if this method should be developed further for whitebark pine.

In Austria, the Federal Nursery has inoculated stone pines (*Pinus cembra* L.) for over 50 years with native ectomycorrhizal fungi and this was found to increase survival of stone pines planted at high elevations from 20 to 80% in one study (Moser 1956, Weisleitner, pers. comm.). The original native inoculum developed by Moser has been maintained over five decades in the nursery apparently without re-introduction, as confirmed by DNA tests that found the original species to present and dominant on roots (figure 2). Interestingly, the main ectomycorrhizal symbiont is *Suillus plorans* (Rolland) Kuntze, a species found strictly with stone pines that is physiologically adapted to high-elevations (Moser 1956). A visit to this nursery showed that pines were inoculated according to a particular and convenient method which we are now attempting to adapt for use in U.S. nurseries.

Commercial inocula should not be used in sensitive whitebark pine systems for several reasons. Most commercial inocula do not contain fungi applicable/native to whitebark pine systems (waste of resources), some could promote competitor tree species, and the introduction of alien fungi is of particular concern for National Parks and wilderness areas. In addition, use of non-native fungi risks upsetting the food chain in these forests since local mammals depend on specific mycorrhizal fungi for food and also disperse their spores (Ashkannejhad and Horton 2005, Izzo et al. 2005). Therefore, it is imperative to use regionally-appropriate native mycorrhizal fungi for inoculation of nursery grown whitebark pine seedlings when inoculation is deemed necessary (Wiensczyk et al. 2002).

Acknowledgments

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References

Ashkannejhad, S., Horton, T.R. 2005. Ectomycorrhizal ecology under primary succession on coastal sand dunes: interactions involving Pinus contorta, suilloid fungi and deer. New Phytologist 169: 345-354.

Brundrett, M., Boucher, N., Dell, B, Grove, T, Malajczuk, N. 1996. Working with Mycorrhizas in Forestry and Agriculture. ACIAR Monograph 32. 374 p.

Bruns, T.D., Bidartondo, M.I., Taylor, L. 2002. Host specificity in ectomycorrhizal communities: what do the exceptions tell us? Integr. Comp. Biol. 42: 352-359.

Burr, K, Eramian, A. Eggleston, K. 2001. Growing whitebark pine seedlings for restoration. In: Tomback, D.F., Arno, S.F. & R.E. Keane, eds. Whitebark Pine Communities: ecology and restoration. Island Press, Washington D.C: 325-345.

Cripps, C.L. 2002. Mycorrhiza. In: Pscheidt J.W. and Ocamb, C.M., eds, Pacific Northwest Plant Disease Management Handbook. Oregon State University Press, Corvallis, OR: 21-23.

Cripps, C.L. (editor) 2004. Fungi in Forest Ecosystems: Systematics, Diversity and Ecology. New York Botanical Garden Press, NY. 363 p.

Cripps, C.L., Mohatt, K. 2005. Preliminary results on the Ectomycorrhizal Fungi of Whitebark Pine Forests. Nutcracker Notes 7: 9-11.

Cripps, C. L., Smith, C, Carolin, T. Lapp, J. 2008. Ectomycorrhizal fungi with whitebark pine. Nutcracker Notes 14: 12-14.

Dumroese, K. 2008. Observations on root disease of container whitebark pine seedlings treated with biological controls. Native Plants Journal 9(2): 92-97.

Izlar, D. 2007. Assessment of whitebark pine seedling survival for Rocky Mountain plantings. M.Sc. Thesis, University of Montana, Missoula, MT.

Izzo, A.D., Meyer, M., Trappe, J.M., North, M., Bruns, T.D. 2005. Hypogeous ectomycorrhizal fungal species on roots and in small mammal diet in a mixed-conifer forest. Forest Science 51: 243-254.

Keane, R.E., Arno, S.F. 2001. Restoration concepts and techniques. In: Tomback, D.F., Arno, S.F. & Keane, R.E., eds. Whitebark Pine Communities: ecology and restoration. Island Press, Washington D.C.: 367-400.

Landis, T., Tinus, R., McDonald, S., Barnett, J. 1990. The Container Tree Nursery Manual. Vol 5: Nursery Pests and Mycorrhizae. USDA FS Agriculture Handbook 674.

Mahalovich, M.F., Dickerson, G.A. 2004. Whitebark pine genetic restoration program for the Intermountain West (United States). In: Sniezko, R.A., Samman, S., Schlarbaum, S.E., Kriebel, H.B., eds. Breeding and genetic resources of five-needle pines: growth, adaptability and pest resistance. Proc RMRS-P-32, USDA FS Rocky Mountain Res. Station, Ft. Collins, CO.: 181-187.

Mohatt, K.R. 2006. Ectomycorrhizal fungi of whitebark pine (Pinus albicaulis) in the Greater Yellowstone Ecosystem. M.Sc. Thesis, Montana State University, Bozeman, MT.

Mohatt, K.R., Cripps, C.L., Lavin M. 2008. Ectomycorrhizal fungi of whitebark pine (a tree in peril) revealed by sporocarps and molecular analysis of mycorrhizae from treeline forests in the Greater Yellowstone Ecosystem. Botany 86: 14-25.

Moser, M.M. 1956. Die Bedeutung der mykorrhiza fur aufforestungen in hochlagen. Forstwiss. Cbl. 75: 8-18.

Moser, M.M. 2004. Subalpine conifer forests in the Alps, the Altai, and the Rocky Mountains: a comparison of their fungal populations. In: Cripps, C.L., editor, Fungi in forest ecosystems: systemtatics, diversity, and ecology, New York Botanical Garden Press, NY: 151-158.

Rincon, A., Parlde, J. and Pera, J. 2005. Effects of ectomycorrhizal inoculation and the type of substrate on mycorrhization, growth and nutrition of containerized *Pinus pinea* L. seedlings produced in a commercial nursery. Ann. For. Sci. 62: 817-822.

Schwandt, J. 2006. Whitebark pine in peril. USDA Forest Service R1-06-28. Missoula, MT.

Smith, S.E., Read, D.J. 1997. Mycorrhizal Symbiosis. Academic Press, Inc., San Diego, CA.

Steinfeld, D., Amaranthus, M., Cazares, E. 2003. Survival of Ponderosa pine (*Pinus ponderosa*) Dougl. Ex Laws.) seedlings outplanted with Rhizopogon mycorrhizae inoculated with spores at the nursery. Journal of Arboriculture 29(4): 197-208.

Tomback, D.F., Arno, S.F. and Keane, R.E. 2001. The compelling case for management intervention. In: Tomback, D.F., Arno, S.F. & Keane, R.E., eds. Whitebark Pine Communities: ecology and restoration. Island Press, Washington D.C: 3-25.

Trusty, P., Cripps, C.L. 2007. Mycorrhizal fungi of whitebark pine seedlings on burns in regard to restoration strategies. Whitebark Pine Foundation Annual meeting, Lincoln, MT. Sept. 28-30, 2007.

Wiensczyk, G. Durall, D., Jones, M., Simard, S. 2002. Ectomycorrhizae and forestry in British Columbia: A summary of current research and conservation strategies. Extension Note. B. C. Journal of Ecosystems and Management 2(1): 1-20.

Wu, Q.-X., Mueller, G.M., Lutzoni, F.M., Huang, Y.-Q., Guo, S.-Y. 2000. Phylogenetic and biogeographic relationships of eastern Asian and eastern North American disjunct Suillus species (fungi) as inferred from nuclear ribosomal RNA ITS sequences. Molecular Phylogenetics and Evolution 17: 37-47.

Survey of *Seiridium* Species Associated with Cypress Canker in Oregon

Danielle Martin[1]

Abstract

Cypress canker is a serious disease caused by species of *Seiridium* that affects many species of *Cupressus* and *Chamaecyparis*, including Port-Orford-cedar. Three species of *Seiridium*, *S. cardinale, S. unicorne* and *S. cupressi* are known to be associated with cypress canker. In an attempt to determine the species of *Seiridium* present on Port-Orford cedar in southwest Oregon we compared ß-tubulin and histone sequences of 8 isolates of *Seiridium* spp. from Port-Orford-cedars with those of fourteen isolates of *Seiridium* species obtained from Genbank. Phylogenetic analysis of sequence data indicated that *Seiridium* isolates from Oregon were most similar to those identified as *Seiridium unicorne.*

Introduction

Port-Orford-cedar (*Chamaecyparis lawsoniana* (A. Murray) Parl.) is one of several Cupressaceae species affected by cypress canker disease, caused by species of *Seiridium.* Three species of *Seiridium* are reported to be associated with cypress canker: *S. cardinale* (Wagener) Sutton & Gibson*, S. unicorne* (Cooke & Ellis) Sutton, and *S. cupressi* (Guba) Bosew (Graniti and Frisullo 1990). Because the three species vary with respect to virulence and ecological characteristics, the ability to distinguish between species of *Seiridium* that are present in an area can provide necessary information for disease management. This research was undertaken to determine the species of *Seiridium* associated with cypress canker symptoms in Port-Orford-cedar trees, and other Cupressaceae, in southwest Oregon. The identity of *Seiridium* species present was determined based on both morphological characteristics and comparisons of DNA sequences of partial ß-tubulin and histone gene regions.

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Seiridium is a genus of anamorphic fungi connected to the genus *Lepteutypa* (Xylariales; Amphisphaeriaceae) Nag Raj 1994, Kirk *et al.* 2001). Three species of *Seiridium* are known to be associated with cypress canker (Graniti and Frisullo 1990). However, the taxonomy of the species has been the subject of considerable debate. There has been some dispute as to whether *S. unicorne* and *S. cupressi* are separate species (Chou 1989). The three species of *Seiridium* pathogenic to Cupressaceae have been differentiated by some authors on the basis of the presence or absence of conidial appendages, and the angle of these structures relative to the main axis of the conidia (Bosewinkel 1983). However, the utility of these characters as a reliable character for distinguishing separate species has been questioned (Barnes *et al.* 2001). Efforts to differentiate species on the basis of ribosomal DNA sequence data (ITS1, ITS2, and 5.8S regions) failed to distinguish among species (Barnes *et al.* 2001, Krokene *et al.* 2004). Barnes *et al.* (2001) demonstrated differences between species of *Seiridium* by analysis of histone and partial ß-tubulin sequences of fourteen isolates of *Seiridium* species. ß-*tubulin* is a protein-encoding gene with both variable and highly conserved regions and has been extensively used in phylogenetic analyses of fungi (Barnes *et al.* 2001 and Krokene *et al.* 2004). This work provided strong evidence that three distinct species of *Seiridium* are associated with cypress canker (Barnes *et al.* 2001). *Seiridium* spp. analyzed by Barnes *et al.* (2001) were obtained from diseased Cupressaceae from Italy, Greece, Portugal, Chile, South Africa, New Zealand, and Australia, but did not include any isolates from western North America or from *C. lawsoniana*. This study was undertaken to determine the species of *Seiridium* associated with cypress canker of Port-Orford-cedar in southwest Oregon.

Methods

In order to assess the diversity of *Seiridium* species present on Port-Orford-cedar in Oregon, preliminary identification of species sporulating on cankers was made directly on the basis of morphological characteristics. *Seiridium* isolates were obtained by transfer of conidia from sporulating cankers to 2% malt agar (Difco, Detroit, MI) and used for comparisons of ß-tubulin and histone sequences. Cankers were collected from *C. lawsoniana* trees in various locations throughout southwest Oregon (Table 3.1).

The sequences used for comparison with Oregon isolates were obtained from GenBank and represented *S. cardinale, S. unicorne, S. cupressi, S. eucalypti* and *S. papillatum. S. papillatum* was included to be used as the outgroup. *S.eucalypti* was included in the analysis because it is very similar in both pathology and morphology to *S. unicorne* and probably represents a synonym of the latter fungus (Barnes *et al*. 2001). Phylogenetic analysis was conducted by alignment with and comparison of ß-tubulin and histone sequences of *Seiridium* isolates collected in southwest Oregon with sequences from GenBank. *Seiridium* isolates collected in Oregon were sequenced at Oregon State University.

Phylogenetic analysis was conducted as described in Barnes *et al.* (2001). Sequence data obtained for 14 *Seiridium* species from GenBank were included for comparison with Oregon isolates. Isolates and taxa used in the phylogenetic analysis are listed in Table 3.1. The two regions of the sequenced ß-tubulin gene and the region sequenced of the histone H3 gene were combined in the analysis. Sequences were aligned with Clustal W (Thompson *et al.* 1994) and adjusted after visual examination. ß-tubulin and histone gene sequences were analyzed using the Phylogenetic Analysis Using Parsimony (PAUP) 4.0 software package (Swofford 2002). Parsimony analyses were carried out using the heuristic search option with tree bisection reconnection (TBR) as the swapping algorithm and 100 random stepwise additions in PAUP.

Results

Morphological characteristics of all specimens of *Seiridium* obtained from cankers of Port-Orford-cedar from Oregon were similar, and agreed most closely with published descriptions of *S. cardinale*. Acervular conidiomata from Port-Orford-cedar cankers were roughly circular, 250 to ~400 µm diam. Conidia were mostly straight or very slightly curved, five-septate (six-celled) with four thick walled median cells and thin walled apical and basal cells. Appendages > 2 µm, characteristic of *S. unicorne*, were lacking from both apical and basal cells of all the Oregon Port-Orford-cedar specimens. Conidia examined ranged between 26.3 to 31.8 µm long and 8.3 to 10.9 µm wide (Figure 1).

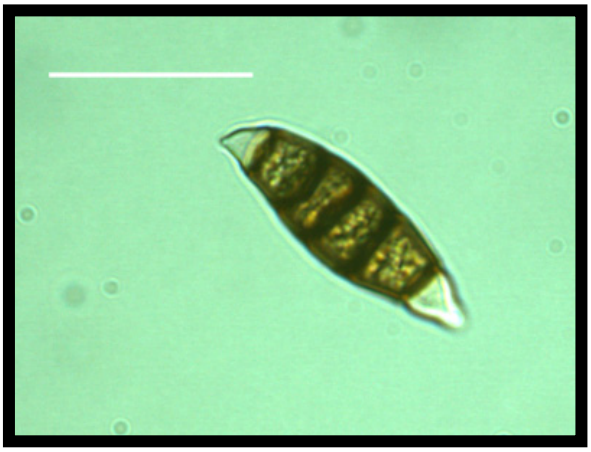

Figure 1. Representative Seiridium conidium from canker on Port-Orford-cedar. Conidium dimensions are 27.5 µm x 8.4 µm.

Phylogenetic analysis

The phylogram generated from the combined ß-tubulin and histone H3 sequences of the representative *Seiridium* isolates resulted in two well supported clades (A and B in Figure 2). Clade A consisted of two subclades, (A_1 and A_2). All *S. cardinale* isolates were resolved in a single clade with a 100% bootstrap value (A_1). Subclade A_2 consisted of *S. cupressi* isolates (bootstrap value 99%). Clade B contained isolates of *S. eucalypti, S. unicorne* and all of the Oregon isolates. *S. unicorne* isolates from Portugal formed a sister clade with the Oregon isolates with an 81% bootstrap value. However, the Oregon isolates grouped in a separate, moderately well supported subclade, distinct from the *S. unicorne* isolates. The

Oregon Seiridium clade had a bootstrap value of 72, but most nodes within the clade had low bootstrap values, reflecting slight variation among the isolates. Two isolates, one obtained from a Port-Orford-cedar in Coos County, Oregon (Dixson) and one obtained from a western redcedar from Douglas County (Battle Axe) occurred together in a single clade with a 78% bootstrap value.

Discussion

Three species of *Seiridium* are known to be associated with cypress canker worldwide (Graniti and Frisullo 1990). It is essential to be able to identify which species of *Seiridium* is present in order to successfully manage Port-Orford-cedar. However, identification of *Seiridium* species from Cupressaceae on the basis of conidium morphology is notoriously unreliable, and to date no molecular data were available for the species of *Seiridium* associated with cypress canker of Port-Orford-cedar in western North America. Examination of conidia from cankers on Port-Orford-cedar trees in southwest Oregon has indicated that the species present most closely resembles *Seiridium cardinale* based upon length of conidia appendages. However, *S. unicorne* exhibits variation in appendage length, sometimes bearing only minute appendages that might be confused with *S. cardinale* (Graniti 1998).

Proper identification of *Seiridium* species is essential because they vary in pathogenicity, host range and ecological attributes. Inoculation trials on several *Cupressus* and *Chamaecyparis* species have shown wide variation in genetic resistance in different hosts to species of *Seiridium.* POC was found to have a high level of resistance to infection by *S. cardinale* but was very susceptible to *S. unicorne* (Spanos *et al.* 2001). *Cupressus macrocarpa* and *C. lusitanica* have been found to be highly susceptibility to *S. cardinale*, and are considered very resistant to *S. unicorne* (Spanos *et al.* 2001). *S. unicorne* has a broader host range and greater variability in virulence than other species of *Seiridium* (Spanos 2001).

More recently, phylogenetic analysis has demonstrated that histone and ß-tubulin gene sequences can be used to distinguish between species of *Seiridium* (Barnes *et al.* 2001, Krokene *et al.* 2004). ß-tubulin is a protein-encoding gene with both variable and highly conserved regions and has been extensively used in phylogenetic analyses of fungi (Barnes *et al.* 2001, Krokene *et al.* 2004). The H3 histone protein is well conserved and is a valuable phylogenetic tool for studying *Seiridium sp.* (Barnes *et al.* 2001). Recent analysis of histone and partial ß-tubulin sequence data showed *Seiridium* isolates from *Cupressus* species to reside in two major clades (Barnes *et al.* 2001). One clade consisted of *S. unicorne* and the closely related *S. eucalypti.* The other clade included a distinct subclade made up solely of *S. cardinale* isolates and another subclade of *S. unicorne* and *S. cupressi* isolates. The occurrence of isolates identified as *S. unicorne* in separate clades underscores the difficulty of differentiating *S. unicorne* and *S. cupressi* based on morphological characters (Barnes *et al.* 2001). Phylogenetic analysis of combined histone and ß-tubulin sequences of the Barnes *et al*. (2001) and Oregon Port-Orford-cedar isolates produced a similar tree. The Oregon isolates were most similar to *S. unicorne* isolates from Portugal, which grouped together on a single well supported branch that formed a sister relationship with the Oregon isolates. The Oregon isolates also occurred on a separate, moderately well supported branch from the *S. unicorne* isolates from Africa and Europe, and appear to constitute a separate taxon. Although differentiating *S. unicorne* and *S. cardinale* on the basis of conidium morphology is known to be unreliable, the grouping of the Oregon isolates more closely with *S. unicorne* than *S. cardinale* was unexpected. Although the Oregon *Seiridium* isolates were morphologically most similar to *S. cardinale*, they occurred in a separate clade from this species in the phlogenetic analysis and appear to be very divergent from *S. cardinale*.

The lack of agreement between the morphological characteristics of the Oregon Port-Orford-cedar isolates and the phylogenetic analysis suggests that there may be greater variation in the morphological characters of *S. unicorne* than previously recognized, or that the *Seiridium* species from Oregon represents a hitherto unrecognized species. Phylogenetic analysis of histone and partial ß-tubulin sequences of Oregon isolates compared with closely related *Seiridium* species showed that the Oregon isolates were more closely related to *S. unicorne* than to *S. cardinale.*

Previously reported analyses of pathogenic *Seiridium* species did not include isolates from North America, which appear more variable than isolates from Europe, New Zealand and Africa. The results of this study indicate some uncertainty as to the identity of the *Seiridium* species associated with cypress canker of Port-Orford-cedar, and suggest that further analyses of *Seiridium* isolates from North America, including additional putative specimens from *C. macrocarpa* are needed to resolve this question.

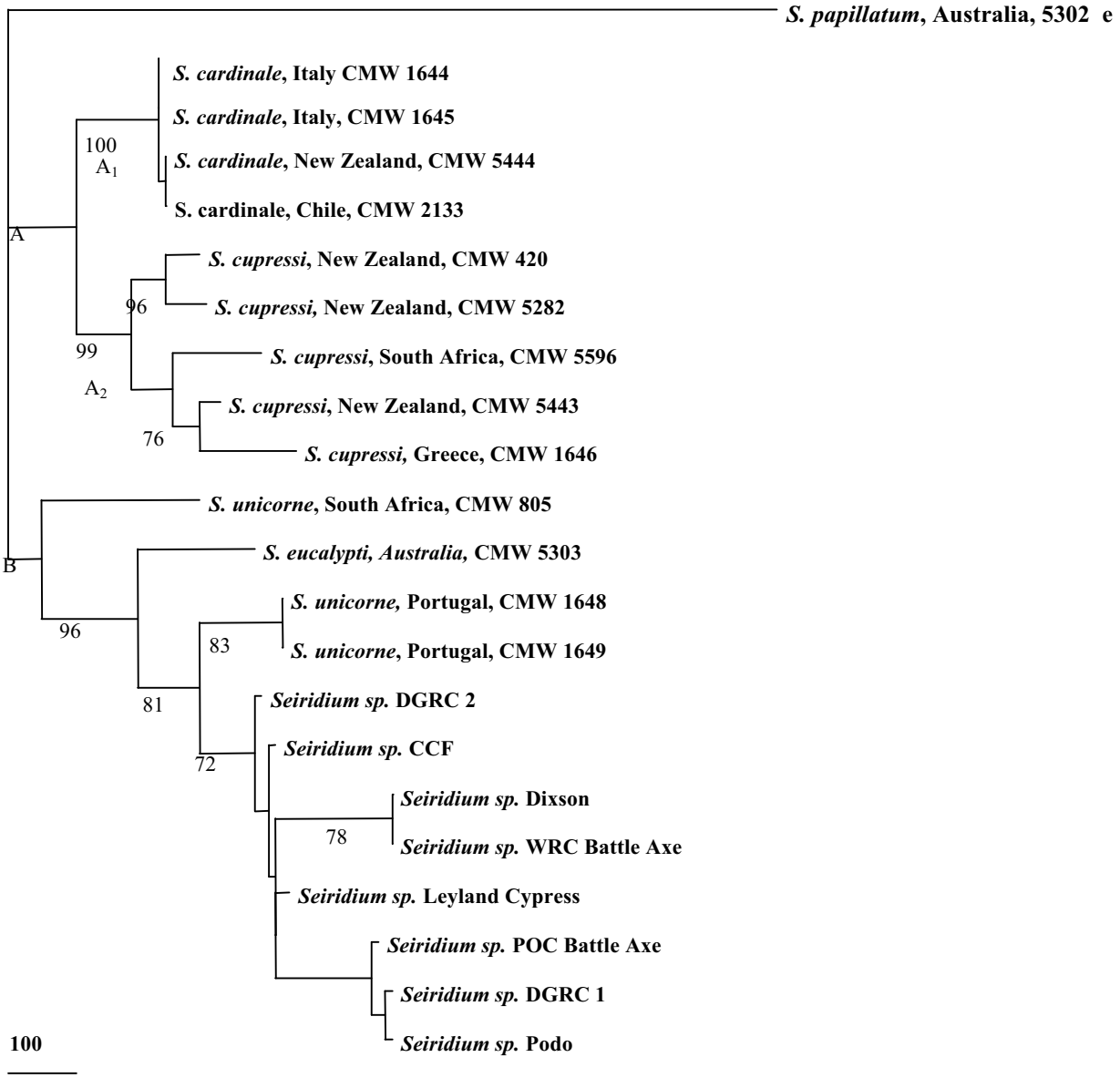

Figure 2. Phylogenetic tree of combined ß-tubulin and histone H3 sequences. The most parsimonious tree was produced using the heuristic search option in PAUP 4 with random stepwise addition and tree bisection reconnection. The tree is rooted with Seiridium papillatum (CMW 5302) as the outgroup. Bootstrap confidence values > 70% are shown below the branches.

References

Barnes I., Roux, J., Wingfield, M.J., Coetzee, M.P.A., Wingfield, B.D. 2001. Characterization of *Seiridium* spp. associated with cypress canker based on ß-Tubulin and histone sequences. Plant Disease 85:317-321.

Boesewinkel, H.J. 1983. New records of the three fungi causing cypress canker in New Zealand, *Seiridium cupressi* (Guba) comb. nov. and *S. cardinale* on *Cupressocyparis* and *S. unicorne* on *Cryptomeria* and *Cupressus.* Transactions of the British Mycological Society 80:544-547.

Chou, C.K.S. 1989. Morphological and cultural variation of Seiridium ssp. From cankered Cupressaccae hosts in New Zealand. European Journal of Forest Pathology 19:435-445.

Graniti, A., Frisullo, S. 1990. The species of *Seiridium* associated with canker diseases of cypress in the Mediterranean area. pp. 82-89 *in*: J. Ponchet (ed.), Agriculture AGRIMED research programme: Progress in EEC research on cypress diseases. Report EUR 12493 EN. Commission of the European Communities. Luxemburg. 144 p.

Krokene, P., Barnes, I.B., Wingfield, M. 2004. A PCR-RFLP based diagnostic technique to rapidly identify Seiridium species casing cypress canker. Mycologia 96(6):1352-1354.

Spanos, K.A., Pirrie, A., Woodward, S. 2001. Screening for resistance to *Seiridium cardinale*, *S. cupressi*, and *S. unicorne* isolates in glasshouse-grown seedlings of Cupressaceae. Silvae Genetica 50:258-64.

Winton L.M., Hansen, E.M. 2001. Molecular diagnosis of *Phytophthora lateralis* in trees, water, and foliage baits using multiplex polymerase chain reaction. Forest Pathology 31:275–283.

Advanced white bark regen set to be killed by fire

Survey of *Armillaria* spp. in the Oregon East Cascades: Baseline Data for Predicting Climatic Influences on Armillaria Root Disease

J.W. Hanna[1], A.L. Smith[2], H.M. Maffei[2], M.S. Kim[1] and N.B. Klopfenstein[1]

Abstract

Root disease pathogens, such as *Armillaria solidipes* Peck (recently recognized older name for *A. ostoyae*), will likely have increasing impacts to forest ecosystems as trees undergo stress due to climate change. Before we can predict future impacts of root disease pathogens, we must first develop an ability to predict current distributions of the pathogens (and their hosts). Reliable predictions depend on knowing precise locations of accurately identified pathogens and their host species. Thus, the goal of this study is to obtain baseline information on *Armillaria* spp. distributions in the East Cascades of Oregon. In 2007, a collaborative project was initiated to survey *Armillaria* spp. associated with diverse geographic areas and climate on the eastern slopes of the Oregon Cascades. Data from this project can be incorporated into models that predict current and future distributions of *Armillaria* spp. based on climatic factors. Models to predict distributions of host tree species are currently available. Consequently, predicted host distributions can be compared with predicted distributions of *Armillaria* spp. to assess potential impacts to forest ecosystems under future climate-change scenarios. The methods developed from this project can provide a basis for the modeling of other important pathogens, and help assess the potential for invasive pathogens under climate-change scenarios. Predictions of Armillaria root disease and other diseases under future climates are essential for forest management to strategically reduce future impacts of disease.

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Introduction

Climate change is predicted to increase the impacts of Armillaria root disease in some regions (Sturrock 2007, Kliejunas et al. 2008). Surveys of *Armillaria* spp. distributions provide necessary baseline information for predicting these impacts (Kim et al. 2008). Although pathogenic species, such as *A. solidipes* (recently recognized older name for *A. ostoyae*; Burdsall and Volk 2008), can be detected in the field by trained forest pathologists, it often goes unnoticed in many areas where it can infect trees below ground without anyreadily apparent, above-ground symptoms (Morrison 2000). In addition, *A. solidipes* frequently persists in a non-pathogenic state until host and environmental conditions favor pathogenicity. Thus, the full distribution of accurately identified *A. solidipes* is not well documented. Well-designed surveys are needed to determine distributions of *A. solidipes* and other less pathogenic *Armillaria* spp. Information of the precise location of accurately identified species can be used to model the suitable climate space for the pathogen, which can then be used to predict current and potential future distributions of *Armillaria* spp. Predictions of potential *A. solidipes* distribution can then be compared with predictions for host tree distributions for preliminary assessments of potential climatic influences on Armillaria root disease.

The goal of this study is to obtain baseline information on *Armillaria* spp. distributions in the East Cascades of Oregon. This information will be used to develop predictions of present and future suitable climate space for *Armillaria* spp., which could correspond to species distributions.

Objectives

(1) Document the distributions of *Armillaria* spp. on diverse hosts across a range of climates and geographic areas in the Oregon East Cascades.

(2) Determine suitable climate space for *A. solidipes* and other *Armillaria* spp. in the East Cascades of Oregon.

(3) Project future suitable climate space for *A. solidipes* and other *Armillaria* spp. in the East Cascades of Oregon under various climate models and emission scenarios.

(4) Incorporate information from predictive models into Disease Risk Models/Maps.

Table 1. Summary of preliminary *Armillaria* spp. isolate identifications for 2007 and 2008 collections from the Oregon East Cascades.

NABS I [a]	NABS III-V-VII complex [b]	NABS X [c] or NABS X x III-V-VII hybrid
36 isolates from 23 plots	140 isolates from 44 plots	121 isolates from 45 plots

Note: Two isolates are not yet identified to species groups. All sequences are currently being analyzed to better characterize these isolates.

[a] North American Biological Species I = Armillaria solidipes (recently known as A. ostoyae)

[b] A complex of closely related species (A. calvescens, A. sinapina, A. gallica)

[c] An unnamed biological species

Table 2. Summary of *Armillaria* spp. by plant association group (PAG) [a].

PAG	Total number of plots sampled	Percent of plots positive for *Armillaria solidipes*	Percent of plots positive for other *Armillaria* spp.	Percent of plots positive for both *A. solidipes* and other *Armillaria* spp.
ABAM Wet	1	100	100	100
ABCO-ABGR Wet	8	38	88	38
ABCO-ABGR Moist	38	21	79	18
ABCO-ABGR Dry	20	5	70	0
ABGR Wet	1	0	0	0
ABGR Moist	2	0	50	0
ABGR Dry	10	30	50	20
TSME Wet	4	0	25	0
TSME Moist	5	0	80	0
TSME Dry	10	40	20	10
TSHE Wet	3	33	67	33
ABMAS Dry	3	33	67	0
PSME Moist	5	0	60	0
PSME Dry	5	0	40	0
PIPO-CADE3 Dry	3	33	0	0
PIPO Dry	40	0	20	0
PIPO Moist	3	0	0	0
PIPO-QUGA Dry	1	0	0	0
PIAL-PICO Dry	1	0	0	0
PICO Dry	3	0	0	0
JUOC Dry	2	0	0	0
Total	168	14	50	9

[a] Twenty-one plots on the Ochoco National Forest were habitat typed based on Johnson and Clausnitzer (1992) and then classified into a PAG equivalent. All other plots were classified into PAGs based on Simpson (2007). ABAM = Abies amabilis, ABCO = Abies concolor, ABGR = Abies grandis, ABMAS = Abies magnifica shastensis, CADE3 = Calocedrus decurrens, JUOC = Juniperus occidentalis, PIAL = Pinus albicaulis, PICO = Pinus contorta, PIPO = Pinus ponderosa, PSME = Pseudotsuga menziesii, QUGA = Quercus garryana, TSHE = Tsuga heterophylla, and TSME = Tsuga mertensiana.

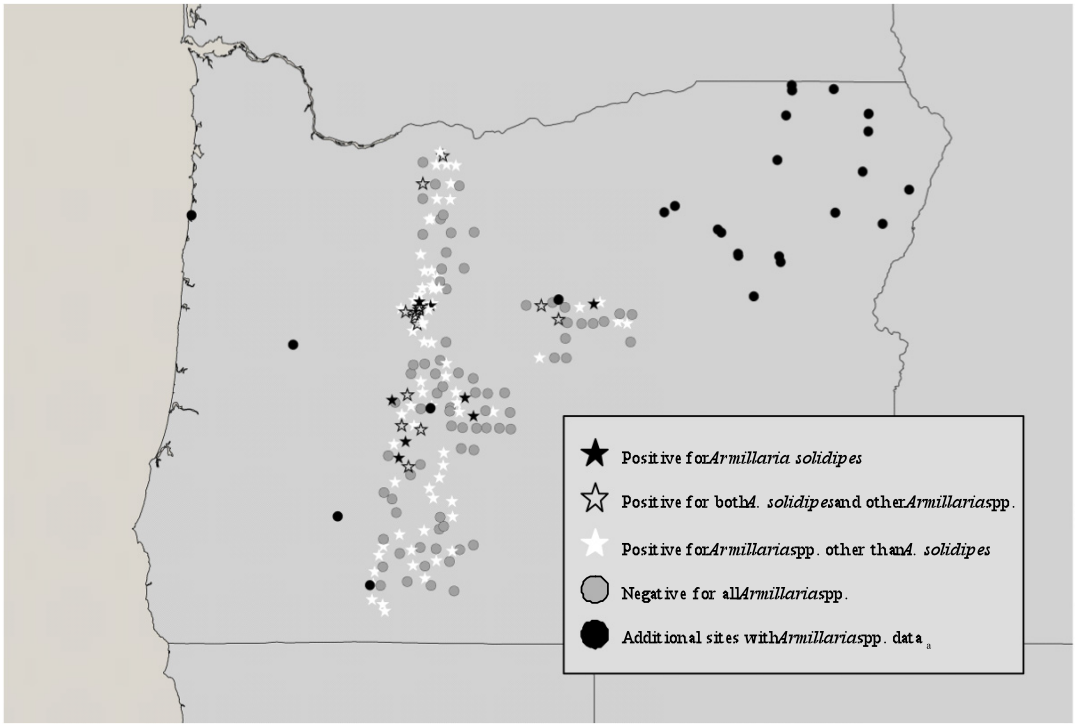

Figure 1. Map of Oregon showing plot locations from 2007 and 2008. Additional sites with Armillaria spp. data suitable for climate modeling (References and/or collector: Ferguson et al. 2003, G.I. McDonald, McDonald et al. 1987, A.L. Smith, and the Intermountain Forest Tree Nutrition Cooperative).

Materials and methods

A total of 168 0.04-ha.plots (119 FY2007 and 49 FY2008) were established across climatically diverse sites in Oregon's East Cascades (e.g., Warm Springs Indian Reservation, Fremont-Winema NF, Deschutes NF, Mt Hood NF, and Ochoco NF). The majority of plots were selected on the basis of climatic diversity and spatial separation across gridded sections (ca. every 7'30" N and 1° 52'30" W). For each tree and shrub species present, primary root systems and butts of three individuals were thoroughly examined, and samples (i.e., rhizomorphs, mycelial fans, rotten wood) of *Armillaria* spp. were collected along with precise location (i.e., latitude, longitude, elevation, slope, and aspect) and associated environmental data (e.g., vegetation type). *Armillaria* spp. isolates were established in culture, then identified with DNA-based techniques (Kim et al. 2006); (tables 1 and 2; and figures 1, 2a, 2b, and 3).

Preliminary results

We identified a total of 36 isolates of *A. solidipes* (NABS I) and 261 isolates of other *Armillaria* spp. using somatic pairing and DNA sequencing methods (table 1). The occurrence of *Armillaria* spp. associated with Plant Association Groups (PAGs) is shown in table 2. Preliminary evidence indicates that the occurrence of different *Armillaria* spp. varies by PAG type (table 2). These surveys will be used to determine suitable climate space for *Armillaria* spp. Once the suitable climate space is determined, the current and potential future distribution of *Armillaria* spp. can be predicted based on interpolated climatic factors across the landscape.

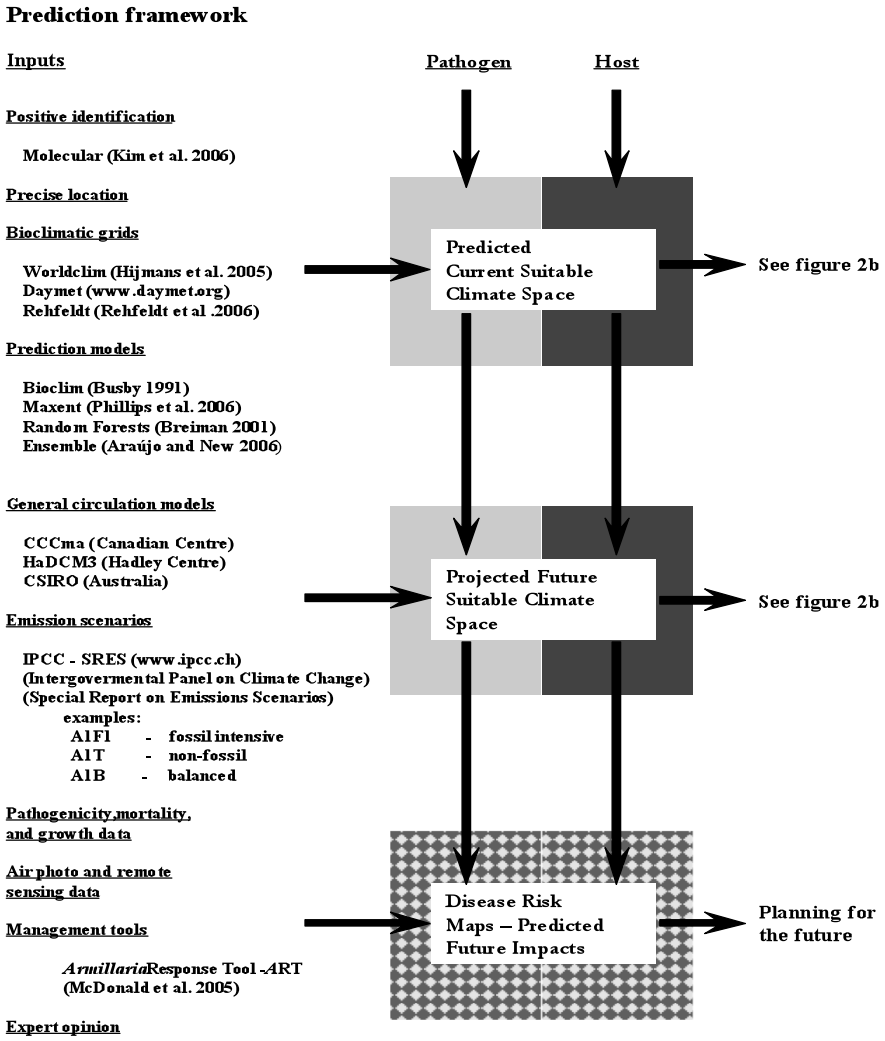

Figure 2a. Prediction framework for determining the impacts of Armillaria root disease in the future.

Future work and refinements

A third field season, to be conducted by the USDA Forest Service Forest Health Protection - Central Oregon Service Center in Bend, OR, is scheduled for 2009 to complete the surveys of Oregon's East Cascades. Continued isolate characterization is also underway at the USDA Forest Service - Rocky Mountain Research Station Forestry Sciences Lab in Moscow, ID. After identification of *Armillaria* spp. isolates is completed, locations confirmed to have *Armillaria* spp. will be used to model suitable climate space (figures 1, 2a, and 2b). This climate window can then be used to predict how various climate change scenarios may affect distribution. Although pathogen distribution may not directly correspond to disease distribution, predictions of pathogen distribution represent an initial step for predicting future disease distribution.

Future tree distribution models show a reduction in suitable climate space for the majority of tree species in the western United States (Rehfeldt et al 2006). In areas where trees become maladapted due to climate change and *A. solidipes* co-exist, it seems reasonable to expect an increase in Armillaria root disease. Weakly pathogenic *Armillaria* spp., also known as saprogens, may also play an increased role in forest disease as trees are stressed by a combination of factors induced by climate change (Boland et al. 2004). The integration of these predictions with other data sources (e.g., pathogenicity, mortality, and

growth data) can form a basis for producing or refining National Insect and Disease Risk Maps (figures 2a and 2b). The incorporation of additional data, such as slope, aspect, soil types, and population structure, should improve precision of future predictions. The methods developed from this project can provide a basis for the modeling of other important pathogens. In addition, these predictions can help assess the potential for invasive species to invade new areas under climate-change scenarios. Predictions of Armillaria root disease under future climates are essential for forest management to strategically reduce future impacts of root disease. Similar approaches can be used to mitigate climate-change impacts on other forest diseases.

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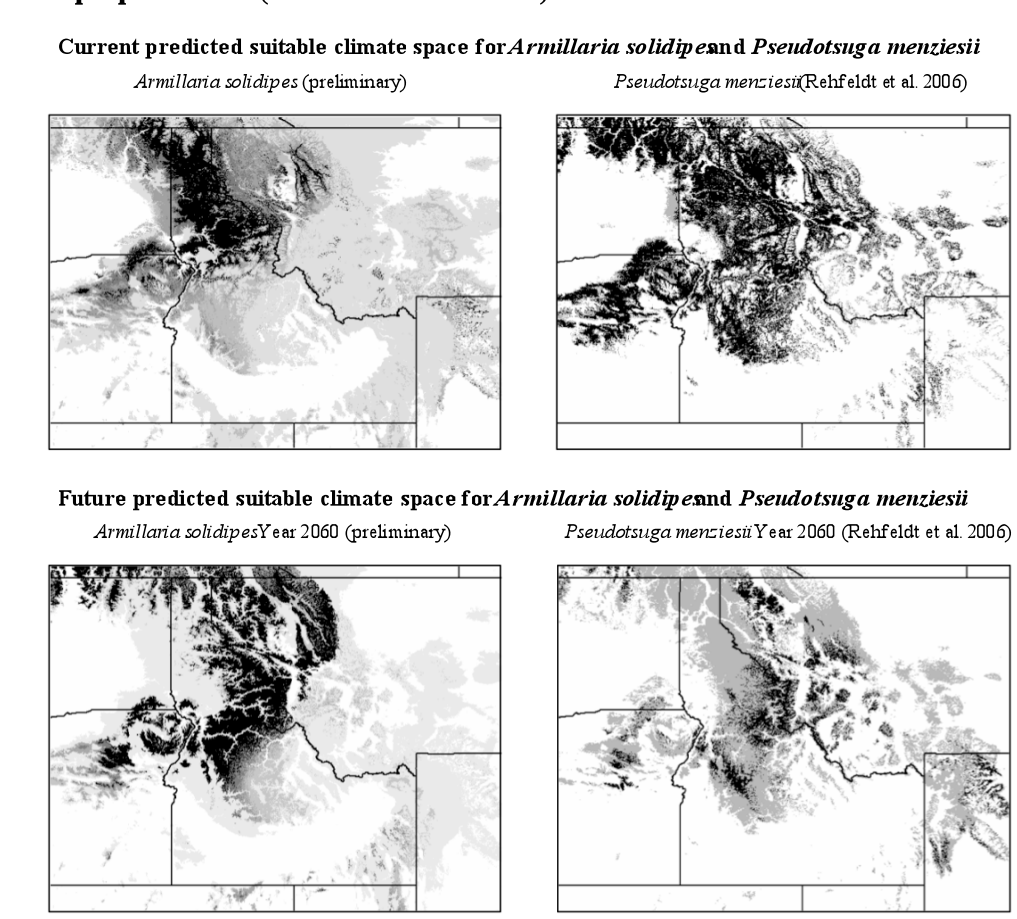

Figure 2b. Preliminary *Armillaria solidipes* predictions for the Inland Northwest, USA, using the Maxent prediction model (based on data from McDonald et al. 1987 and climate surfaces developed by Rehfeldt et al. 2006). The *A. solidipes* predictions are shown on a gradient from black (high suitability) to light grey (low suitability). The *Pseudotsuga menziesii* models use the Random Forest prediction model, black indicates suitable habitat for *Pseudotsuga menziesii* (>75% Random Forest decision tree votes) and grey indicates less suitable habitat (50-75% Random Forest decision tree votes) (Rehfeldt et al. 2006).

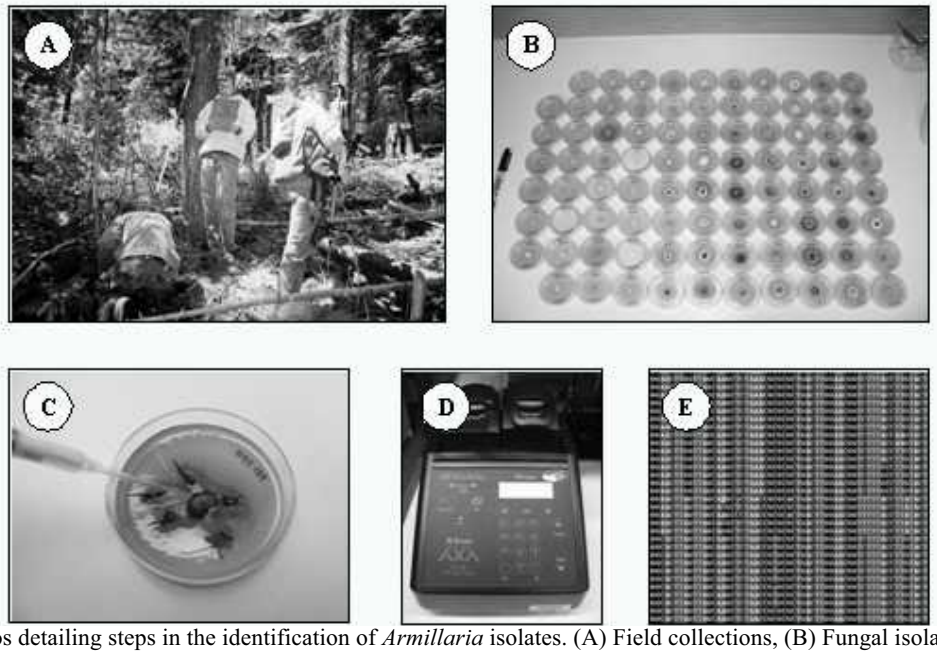

Figure 3. Photos detailing steps in the identification of *Armillaria* isolates. (A) Field collections, (B) Fungal isolation, (C) DNA scrapings, (D) PCR thermocycler, and (E) Data analysis.

References

Araújo, M.B., New M. 2006. Ensemble forecasting of species distributions. TRENDS in Ecology and Evolution 22: 42-47.

Boland, G.J., Melzer, M.S., Hopkin, A., Higgins, V., Nassuth, A. 2004. Climate change and plant diseases in Ontario. anadian Journal of Plant Pathology 26: 335-350.

Breiman, L. 2001. Random Forests. Machine Learning. 45: 5-32.

Busby, J.R. 1991. BIOCLIM - A bioclimatic analysis and prediction system. In: Margules, C.R. & M.P. Austin (eds.) Nature conservation: cost effective biological surveys and data analysis. Canberra: CSIRO. pp. 64-68.

Hijmans, R.J., Cameron, S.E., Parra, J.L., Jones, P.G., Jarvis, A. 2005**.** Very high resolution interpolated climate surfaces for global land areas. International Journal of Climatology 25:1965-1978.

Ferguson, B.A., Dreisbach, T.A., Parks, C.G., Filip, G.M., Schmitt, C.L. 2003**.** Coarse-scale population structure of pathogenic *Armillaria* species in a mixed-conifer forest in the Blue Mountains of northeast Oregon. Canadian Journal of Forest Research 33: 12-623.

Johnson, C.G., Clausnitzer, R.R. 1992. Plant associations of the Blue and Ochoco Mountains. P6-ERWTP- 036-92. Portland, OR: USDA Forest Service, Pacific Northwest Reigion. 164 p. + appendices.

Kim, M.-S., Klopfenstein, N.B., Hanna, J.W., McDonald, G.I. 2006. Characterization of North American *Armillaria* species: Genetic relationships determined by ribosomal DNA sequences and AFLP markers. Forest Pathology 36: 145-164.

Kim, M.-S., Klopfenstein, N.B., Richardson, B.A., Hanna, J.W., McDonald, G.I. 2008. Toward determining the influence of climate change on Armillaria root disease in western North America. Phytopathology 98: S192 (Abstract).

Kliejunas, J.T., Geils, B., Glaeser, J.M., Goheen, E.M., Hennon, P., Kim, M-S., Kope, H.; Stone, J., Sturrock, R., Frankel, S. 2008. Climate and forest diseases of western North America: a literature review. Albany, CA. U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station. 36 p.

McDonald, G.I., Martin, N.E., Harvey, A.E. 1987. Occurrence of *Armillaria* spp. in the forests of the northern Rocky Mountains. Res. Note INT-381. Ogden, UT: U.S. Department of Agriculture, Intermountain Research Station. 7 p.

McDonald, G.I., Tanimoto, P.D., Rice, T.M., Hall, D.E., Stewart, J.E., Zambino, P.J., Tonn, J.R., Klopfenstein, N.B., Kim, M.-S. 2005. Fuels planning: science synthesis and integration; environmental consequences fact sheet 13: Root Disease Analyzer-*Armillaria* Response Tool (*A*RT). RMRS-RN-23-13WWW. Fort Collins, CO: U.S. Department of Agriculture, Rocky Mountain Research Station. 2 p.

Morrison D.J. 2000. Armillaria root disease: A major impediment to sustainable management of southern Interior ecosystems. In: Proceedings, From science to management and back: a science forum for southern interior ecosystems of British Columbia. C. Hollstedt, K. Sutherland, and T. Innes (editors). Kamloops, B.C. :Southern Interior Forest Extension and Research Partnership. pp.23–26.

Phillips, S.J., Anderson, R.P., Schapire, R.E. 2006. Maximum entropy modeling of species geographic distributions. Ecological Modeling 190: 231-259

Rehfeldt, G.E., Crookston, N.L., Warwell, M.V., Evans, J.S. 2006. Empirical analyses of plant-climate relationships for the western United States. International Journal of Plant Science 167: 1123-1150

Simpson, M. L. 2007. Forested plant associations of the Oregon East Cascades. R6-NR-ECOL-TP-03-2007. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Region. 575 p.

Sturrock, R.N. 2007. Climate change effects on forest diseases: an overview. In: Jackson, M.B. (comp). Proceedings 54th Annual Western International Forest Disease Work Conference, October 2-6, 2006, Smithers, B.C. pp. 51-55.

Carlson Ridge, Bitterroot National Forest, 2008 Montana

Wood Decay Fungi Associated with Beetle-Killed Lutz Spruce (*Picea* x *lutzii*) from the Kenai Peninsula, AK: Culture Studies

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Abstract

Beetle-killed trees present a serious fire hazard for Alaska's Kenai Peninsula. A key component of understanding decomposition patterns is the identification of wood decay fungi. The isolation of fungi in culture from wood at different stages of decay is a standard procedure used in many ecological studies, but little is known about the biases and limitations of using cultural methods to sample fungal communities. Here we present cultural data that will later be compared to identifications made by sequencing fungal DNA isolated directly from wood samples and identifications of fruiting bodies. Beetle-killed Lutz spruce trees (*Picea x lutzii*) representing decay classes 2 - 4 (least to most decayed) were selected in the Dry Gulch stand of the Chugach National Forest. Snags (standing, decay class 2) and logs (fallen, decay class 2, 3, and 4) were sampled between 3 - 4 m from their base by aseptically drilling 5 holes on opposite sides at 20 cm intervals (10 holes per log). Six chips per sample were placed in each of 4 different culture media. A total of 1147 cultures were ultimately isolated from 8 logs and 3 snags, of which 647 were successfully sequenced and identified by their DNA. The fewest unique taxa were isolated from the decay class 2 snags, but they included important decay species. The greatest number of taxa was obtained from decay class 2 logs. The inclusion of the fungitoxicants benomyl and metalaxyl did not significantly increase the number of decay basidiomycetes recovered. The brown-rot fungus *Fomitopsis pinicola* was recovered in all decay classes and appears to be the dominant decay fungus in beetle-killed spruce.

Key words: spruce bark beetle, Lutz spruce, decay fungi, *Fomitopsis pinicola.*

In: Baker, F.A. comp. 2008. Proceedings of the 56th Western International Forest Disease Work Conference; 2008 October 27-31; Missoula, MT. Logan, UT: USU Dept. of Wildland Resources.

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Introduction

Massive infestations of the spruce bark beetle (*Dendroctonus rufipennis*) in the 1990s killed 3.4 million acres of Lutz (*Picea* x *lutzii*), white (*Picea glauca*) and Sitka (*Picea sitchensis)* spruce on Alaska's Kenai Peninsula, often exceeding 90% mortality of the overstory (Ross et al., 2001). Although such infestations have declined in recent years (Forest Health Protection Reports 2003, 2008), such mortality has created huge accumulations of dead wood that pose a serious fire hazard in the area. An ecological analysis of the Lutz spruce debris (Harmon et al, 2005) concluded that the standing dead snags had a very low rate of decomposition except at their base. When this basal wood failed, the snag would fall to the forest floor where exposure to soil moisture would allow the growth of decay fungi, increasing the decomposition (weight loss) rate from essentially zero to approximately 1.5% per year. Based on these decay rates, it was estimated that the coarse woody debris associated with these beetle-killed trees would affect fire behavior for at least 75 years and it would take more than 200 years for the trees to decay completely. Decomposition rates were quite variable among sites and also among individual trees, especially when grasses dominated the understory and restricted access to soil moisture.

A key component of understanding decomposition patterns and their influence on fire hazard is the identification of the fungi responsible for decay. Decay fungi are associated with different types of decay that influence the rate of decomposition and the amount and type of material that is ultimately sequestered on the forest floor. Brown-rot fungi degrade the cellulose and hemicellulose of wood but do not metabolize lignin, thus allowing almost 30% of wood carbon to be integrated into humus – the light organic carbon fraction (Larson et al, 1980). White-rot fungi metabolize all three types of wood carbohydrates, releasing most of the products as water and carbon dioxide so that minimal amounts enter the

soil as dissolved organic carbon (DOC) which is adsorbed onto clay in the heavy soil organic carbon fraction. Humus resulting from brown-rot is an integral component of fire hazard prediction models such as the Canadian System Fire Weather Index (National Resources Canada, 2009) as this fraction is more flammable than the clay-sorbed carbon fraction resulting from white-rot.

Certain decay fungi are associated with small branches and twigs while others degrade the bole of the tree (Griffith, 1977; Griffith and Boddy, 1991). Heart-rot fungi decay from within and are usually pathogens of live trees, while sap-rot fungi start degrading the outer sapwood, moving towards the center of the tree after death. Decay fungi have different moisture requirements so that some can degrade material that is quite dry (Boddy, 1983; Griffin, 1977; Loman, 1965; Rayner, 1985). Although most species require moisture contents of 30% or higher, *Gloeophyllum saepiarium* and *Phlebia subserialis* can decay wood at lower moisture contents and higher temperatures than most and are often found in the driest portions of slash piles or on case-hardened logs (Loman, 1962; Loman 1965; Spaulding 1929; Spaulding, 1944). Knowledge of the decay fungi associated with the beetle-killed spruce would give us additional information about future decomposition rates and patterns.

Currently there are three primary means of assessing the diversity of wood decay fungi in coarse woody debris: 1) surveys of reproductive structures, 2) culture of fungi on artificial media, and 3) identification of DNA isolated directly from wood samples. Traditionally, microscopic examination of fruiting bodies formed on the decayed wood was the standard protocol. Not all decay fungi form fruiting bodies, however, or their formation may be restricted and associated with a particular stage of decay or a certain combination of environmental factors. Thus, an inventory of fruiting bodies will miss many decay fungi that are present in the wood but not currently fruiting.

The isolation of fungi in culture from wood at different stages of decay is also a standard procedure used in many ecological studies, but little is known about the biases and limitations of using cultural methods to sample fungal communities. Many decay fungi grow slowly in culture and are overwhelmed by rapid growth of saprotrophic molds. The addition of fungitoxicants, such as benomyl, that suppress the growth of fungal contaminants can be helpful, but many imperfect fungi and zygomycetes are not inhibited by these chemicals. Slow-growing decay fungi can also be suppressed by fast-growing fungi. Fungi growing in culture can also be difficult to identify because distinguishing characters, such as spores, are rarely produced under cultural conditions. The ability to sequence DNA from sterile isolates has greatly increased the number of fungi that can be identified in culture. Sequencing of DNA from cultures was the primary means of identification used in this study, although microscopic characters (e.g. presence of clamp connections, spores, etc.) were sometimes used to confirm identifications.

In addition to DNA-sequencing of cultures, DNA-based techniques are also being developed to directly assess fungal diversity in decaying wood, but these techniques are still in the early stages of development (Czederpiltz and Stenlid 2004, Lindner et al 2006, Guglielmo et al 2007). The use of DNA to analyze fungal communities in wood shows great promise, but there are still many technical issues that need to be addressed. While DNA-based sampling can theoretically detect all fungal species, regardless of whether they are fruiting or whether they can be grown on artificial media, these techniques are often expensive, difficult to apply to large numbers of samples, and careful measures are needed to avoid DNA contamination. The inherent biases associated with these techniques have not been thoroughly investigated, and even simple issues, such as degradation of DNA in stored samples, need to be addressed before these techniques are widely employed. The culture-based data presented in this paper will serve as a basis for future studies comparing the effectiveness of DNA-based methods.

An important tool in the designation of decay patterns is the concept of decay class (DC), which numerically describes the amount of decay in a log or snag on a defined scale. Different definitions of decay class have been published (Harmon et al, 2005; Lowell and Willits, 1998; Maser, C. et al, 1979; Sollins, 1982; Triska and Cromack, 1980). Harmon et al. (2005) used the 5-point scale adapted from Maser et al. (1979), with DC 1 being the least decayed and DC 5 the most decayed. In this system, the amount of remaining bark, twigs, branches, needles, the overall shape of the log, and the texture of the remaining

wood are all used to define decay classes. We have followed this decay scale for the current work.

The goal of this study was to follow fungal succession in beetle-killed trees in plots previously studied by Harmon et al. (2005) from the time they were DC 2 snags and logs until they became DC 4 logs. Logs in DC 4 pose less fire danger than logs in earlier stages of decomposition. Decay class 1 logs and snags were not included in the study due to the low probability of recovering decay fungi from freshly killed material. The fungal community was assessed by collecting fungal fruiting bodies and by culturing fungi from wood samples on different selective media. This study will serve as a baseline to compare future assessments of the fungal community using DNA-based techniques and provides an estimate of the sampling effort needed to characterize the diversity of culturable fungi in spruce logs and snags representing different decay classes.

Materials and Methods

In August 2004, beetle-killed Lutz spruce on a northern slope of the Dry Gulch stand (60^{o} 46' 18.02" N; 149 ^{o} 25' 48.17" W) of the Chugach National Forest on Alaska's Kenai Peninsula were surveyed and assigned to decay class based on the descriptions of Harmon et al (2005). Snags (standing, DC 2) and logs (fallen, DC 2, 3, 4) were sampled. A total of 11 trees were sampled: 3 DC 2 snags, 3 DC 2 logs, 3 DC 3 logs, and 2 DC 4 logs. Snags were felled immediately before sampling, and samples were taken between 3 - 4 meters from the base of the tree by aseptically drilling 5 holes on opposite sides at 20 cm intervals (10 holes per log or snag). All bark was striped from the tree before the holes were drilled and the surface at sample points was flame-sterilized until carbonized before drilling. Six wood chips per drill hole were placed in each of 4 different preparations of 2% malt extract agar that included streptomycin sulfate (100 mg/l) alone (MEA-S) and in combination with benomyl (1 mg/l), and/or metalaxyl (10 ppm). Resultant cultures were subcultured until pure.

Species identifications were made by sequencing the internal transcribed spacer (ITS) region of nuclear ribosomal DNA and comparing the sequence to known sequences in GenBank (NCBI). Sequencing procedures followed those of Lindner and Banik (2009), with the exception that DNA was isolated from blocks of agar approximately 8 mm by 8 mm excised from the growing margin of each colony. Sequences were assigned a putative identification base on BLAST comparisons to GenBank sequences. Sequences varying less than 2% in base pair identity were considered the same and were designated as "taxa." Taxon accumulation curves were generated using Sanders' (1968) rarefaction equations as modified by Hurlbert (1971). These equations allow for the exact calculation of the mean taxon accumulation curve over all possible permutations of sampling order. Fruiting bodies were also collected at the time of sampling, dried, and identified using traditional morphological characteristics

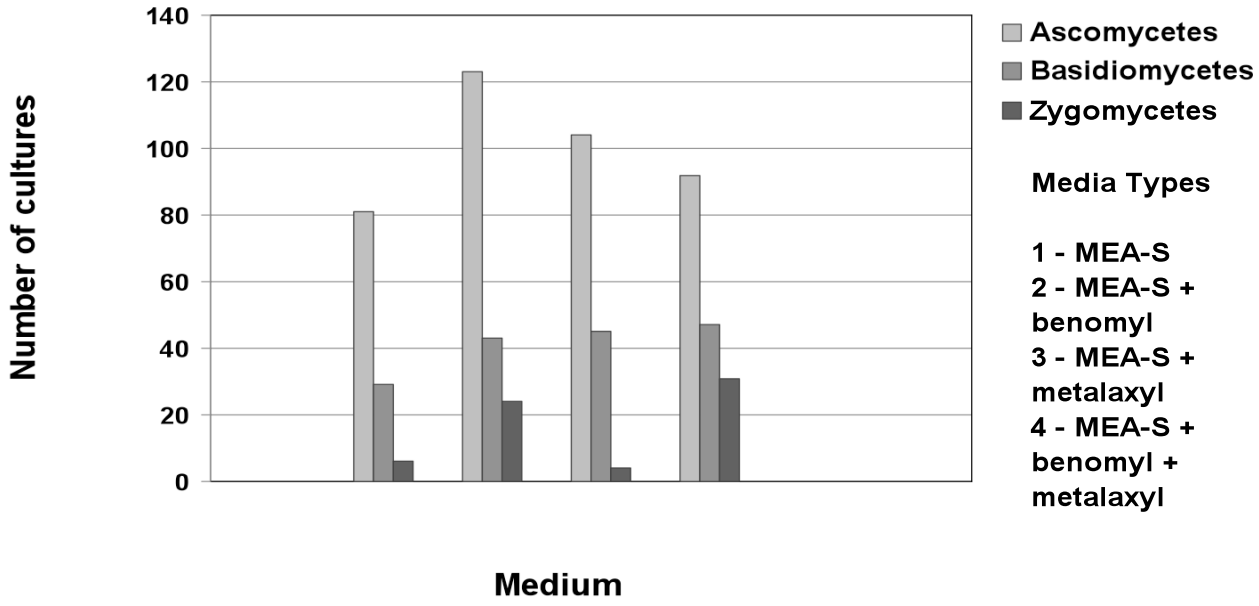

Figure 1: Number of fungal cultures isolated and identified by culture medium.

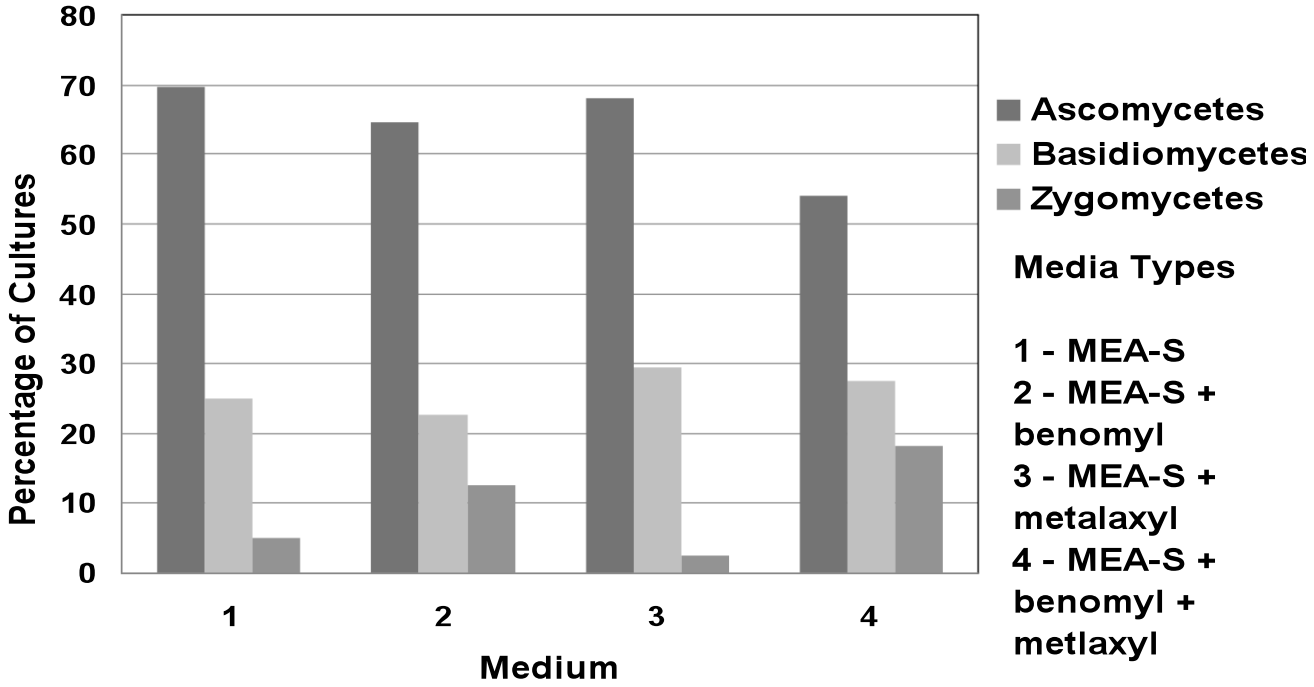

Figure 2: Percent of fungal cultures isolated and identified by culture medium.

Results and Discussion:

A total of 1147 cultures were ultimately isolated from 8 logs and 3 snags; 647 cultures (56%) were successfully identified by DNA sequencing of the ITS region. The remaining 500 cultures produced insufficient PCR products for sequencing. The success rate of sequencing was somewhat low, but nonetheless exceeds the success rate typically observed when traditional microscopic methods are used for cultural identification. The results of culturing and fruiting body identifications are presented in Tables 1 – 4. Species richness of culturable fungi was greatest in DC 2 logs. Sixty-nine taxa were isolated from DC 2 logs, with an average of 27 taxa per log. Species richness was lowest in DC 2 snags, with 16 total species and an average of 6 taxa per snag. Although few species were found in DC 2 snags, the list of species contained important wood decay basidiomycetes, including *Fomitopsis pinicola*. Fungi that are known to be important decay agents were increasingly difficult to culture in DC 3 and DC 4 logs, despite the presence of fruiting bodies. In fact, the only known decay fungus isolated from DC 4 logs was *Fomitopsis pinicola*, despite the presence of fruiting bodies of other brown- and white-rot fungi. Ascomycetes, including mitosporic forms, were the most commonly cultured fungi from all decay classes. Basidiomycetes were second, followed by zygomycetes. Zygomycetes were the most prevalent in highly decayed material (DC 4). It is unknown whether live mycelia of decomposer basidiomycetes are no longer present in logs at such advanced states of decay or whether these fungi simply cannot be cultured due to competition from fast-growing zygomycetes and asexual stages of ascomycetous fungi.

Far fewer fungi were associated with the DC 2 snags than DC 2 logs. This was expected since the snags rapidly dry upon tree death and may be below the fiber saturation point necessary for growth of most fungi. The largest number of culturable taxa was associated with DC 2 logs, while the largest number of fruiting bodies was found on DC 3 logs. This also is not surprising since many of the culturable fungi were ascomycetes, including their imperfect forms, which are often associated with the early stages of fungal succession (Schmidt, 2006). Fruiting bodies generally develop on wood only after a critical mass of mycelium has colonized the tissue; this would occur later in the decay process (Schmidt 2006).

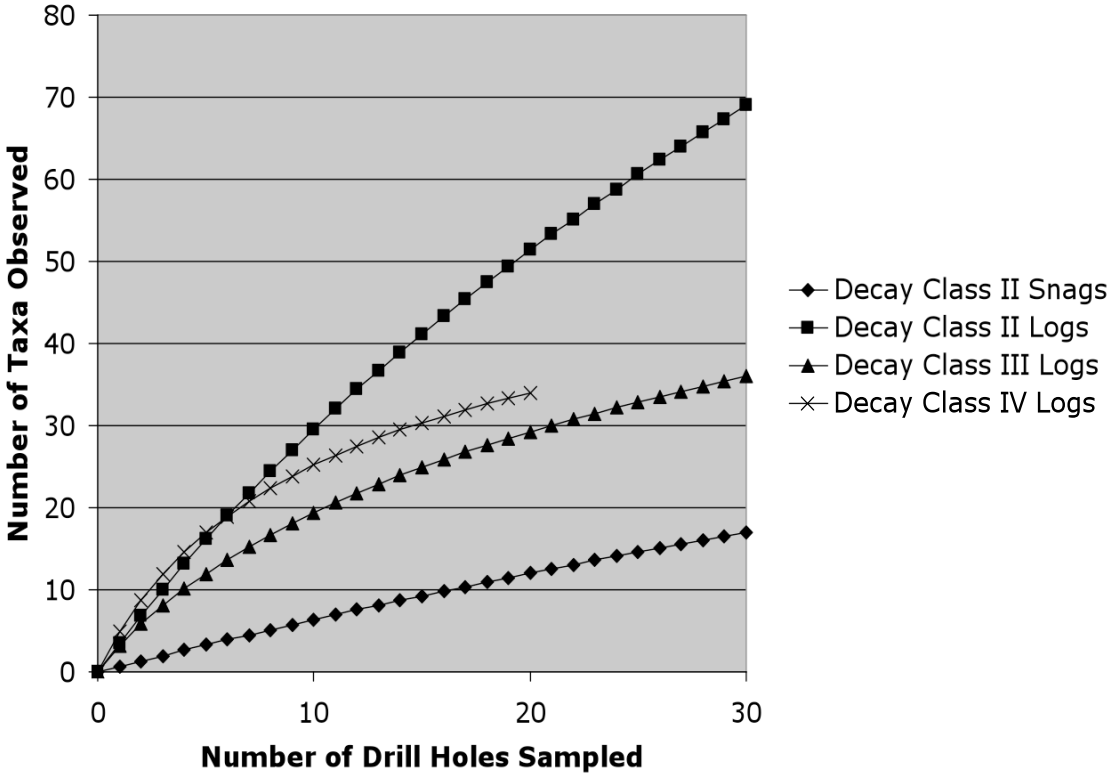

Figure 3: Taxon accumulation curves.

Table 1: Fungal fruiting bodies and cultured fungi from Decay Class 2 snags [a]

Cultures	Frequency (# drill holes)	Fruiting Bodies
unknown (unk) Ascomycete B[b]	2	***Fomitopsis pinicola***
Fomitopsis pinicola	2	
***Phellinus* sp.**	2	
Ampelomyces humuli	1	
unk. Ascomycete DD	1	
unk. Ascomycete II[c]	1	
unk. Basidiomycete DD[d]	1	
Pseudoeurotium sp.	1	
Peniophora sp.	1	
Phaeoacremonim rubrigenum	1	
Pycnoporus cinnabarinus	1	
Sistotremastum sp.	1	
Sistotrema sp.	1	
Thanetephorus cucumeris	1	
Trametes versicolor	1	
Xenochalara sp.	1	

[a]Culture identification based on GenBank search of ITS sequence data. Basidiomycetes shown in boldface.
[b]Most closely related to *Stachybotrys* sp. [88% base pair (BP) match]
[c]Most closely related to *Candida* sp. (95% BP match, 5.8s only)
[d]Most closely related to *Fuscoporia* sp. (88% BP match)

Most of the fungi were only cultured from one or two sampling points in the log or snag, demonstrating the complexity of fungal growth within decayed wood where numerous fungi are competing for limited resources. These data are consistent with data from *Picea* logs in Sweden obtained by of Vasiliauskas et al (2005). Many basidiomycete fungi were cultured that did not appear as fruiting bodies, and many species found as fruiting bodies were not isolated in culture. Both white-rot and brown-rot fungi were isolated in culture and found as fruiting bodies. *Fomitopsis pinicola* was the most commonly detected decay fungus, appearing in culture and as fruiting bodies in all decay classes. It appears to be the dominant decay fungus in beetle-killed Lutz spruce. Traditionally considered a wound fungus, the ubiquitous *F. pinicola* spores can enter through wounds such as fire scars, beetle tunnels and branch stubs and is most destructive in standing trees that have been killed by other causes (Tainter and Baker, 1996). Although the spruce bark beetle is not known to be an active vector of the fungus, it may carry spores on its body and passively inoculate trees upon feeding, as has been shown for other beetles (Petty and Shaw, 1986). *Fomitopsis pinicola* is a major producer of brown cubical decay in western forests (Gilbertson and Ryvarden, 1986). Its association with such large volumes of beetle-killed material suggests that large quantities of this wood carbon will eventually be incorporated into the humus layer.

The type of culture medium used did not seem to significantly affect the species composition of fungi that were isolated (Figures 1 and 2). The incorporation of metalaxyl and benomyl, alone and in combination, only slightly increased the number of wood decay basidiomycetes that were recovered compared to the non-amended medium. This was not expected since benomyl-amended media have been used routinely for decades to isolate decay fungi from wood.

The taxon accumulation curves for cultures (Figure 3) indicate that additional sampling would detect many more species of fungi in all decay classes. Decay class 4 logs had the flattest taxon accumulation curve, but even this curve had not leveled off entirely with our maximum sampling intensity. The amount of labor necessary to achieve the level of sampling that would detect all possible fungi, or even the majority of all possible fungi, would be costly, both in the field and the laboratory and is generally not feasible.

Future research will compare these sampling techniques to identifications made by sequencing of fungal DNA directly from wood samples, with the ultimate goal of determining the best sampling protocols for the ecological assessment of wood decay fungi.

Table 2: Fungal fruiting bodies and cultured fungi from Decay Class 2 logs [a]

Cultures	Frequency (# drill holes)	Fruiting bodies
Fomitopsis pinicola	7	***Coniophora olivaceae***
Amylostereum chailletii	4	***Fomitopsis pinicola***
unknown (unk.) Ascomycete C	4	***Phellinus ferrugineofuscus***
Thysanophora penicilliodes	4	***Sistotrema* sp.**
Pseudoeurotium sp.	3	***Trichaptum abietinum***
Penicillium swiecicki	3	
Penicillium thornii	3	
Peniophora aurantiaca	3	
Phialophora lagerbergii	3	
unk. Ascomycete HH	2	
unk. Ascomycete KK[b]	2	
unk. Ascomycete QQ	2	
Calycina herbarum	2	
Chondrostereum purpureum	2	
Coniophora olivaceae	2	
***Phellinus* sp.**	2	
Sistotrema brinkmannii	2	
Trichaptum fusco-violaceum	2	
Acanthophysium lividocaeruleum	1	
Ampelomyces humuli	1	
***Amphinema* sp.**	1	

Table 2 (cont.): Fungal fruiting bodies and cultured fungi from Decay Class 2 logs [a]

Cultures	Frequency (# drill holes)	Fruiting bodies
Antrodia serialis	1	
unk. Ascomycete AA[c]	1	
unk. Ascomycete E	1	
unk. Ascomycete NN[d]	1	
unk. Ascomycete OO	1	
unk. Ascomycete PP[e]	1	
unk. Ascomycete RR[f]	1	
unk. Ascomycete SS[g]	1	
unk. Ascomycete TT	1	
unk. Basidiomycete C	1	
Diaporthe phaesolorum	1	
***Gymnopus* sp.**	1	
Gyoerffyella sp.	1	
Hypocrea minutispora	1	
Hypocrea sp.	1	
Lachnum sp.	1	
Lecythophora sp.	1	
Microdochium phragmitis	1	
Penicillium miczymskii	1	
Penicillium citrinum	1	
Phaeoacremonium rubrigenum	1	
Phanerochaete sordida	1	
Phellinus nigrolimatus	1	
Phellinus pini	1	
Phialocephala fusca	1	
Phialocephala scopiformis	1	
Rhinocladiella atrovirens	1	
Sarea difformis	1	
Stereum sanguinolentum	1	
Thanatephorus cucumeris	1	
Trametes versicolor	1	
Trichaptum sp.	1	
Trhicoderma viride	1	
Tyromyces chionensis	1	
Zalerion arboricola	1	
unk. Zygomycete A	1	
unk. Zygomycete B	1	

[a]Culture identification based on GenBank search of ITS sequence data. Basidiomycetesshown in boldface.
[b]Most closely related to *Dactylaria sp*. [89% base pair (BP) match].
[c]Most closely related to *Phialocephala virens* (88% BP match).
[d]Most closely related to *Beauveria virella* (83% BP match).
[e]Most closely related to *Sporothrix sp*. (98% BP match, 5.8s only).
[f]Most closely related to *Candida sp*. (98% BP match, 5.8s only).
[g]Most closely related to *Beauveria virella* (93% BP match, 5.8s only).

Table 3: Fruiting bodies and cultures from Decay Class 3 logs [a]

Cultures	Frequency (# drill holes)	Fruiting bodies
Cephalosporium sp.	15	**Amphinema byssoides**
Fomitopsis pinicola	13	**Antrodia serialis**
unknown (unk.) Ascomycete CC[b]	5	**Athelia arachnoidea**
Ascocoryne sp.	4	**Botryobasidium botryosum**
Hypocrea sp.	4	**Botryobasidium medium**
Penicillium thomii	4	**Botryobasidium sp.**
Phialophora sp. A	4	**Coniophora olivaceae**
Thysanophora penicilliodes	4	**Fomitopsis pinicola**
unk. Ascomycete C	4	**Hyphoderma praetermissum**
Postia sp.	3	**Hyphderma sambuci**
unk. Zygomycete H	3	**Phanerochaete laevis**
Lachnum sp.	3	**Phellinus ferrugineofuscus**
Penicillium miczymskii	2	**Pluteus sp.**
Pesotum sp.	2	**Trichaptum abietinum**
Phialophora lagerbergii	2	**Xeromphalina sp.**
Talaromyces sp.	2	
Thanatephorus cucumeris	2	
unk. Ascomycete BB[c]	1	
Ascocoryne cylichnium	1	
Dichostereum granulosum	1	
unk. Basidiomycete K[d]	1	
Coprinus radians	1	
Lecythophora sp.	1	
Penicillium soppii	1	
Phaeoacremonium rubrigenum	1	
Phellinus sp.	1	
Phialophora sp. E[e]	1	
Phialocephala fusca	1	
Pholiota squarrosa	1	
Sistotrema sp.	1	
Sporothrix sp.	1	
Typhula sp.	1	
unk. Zygomycete A	1	
unk. Zygomycete G	1	

[a]Culture identification based on GenBank search of ITS sequence data. Basidiomycetes shown in boldface.
[b]Most closely related to *Calonectria* sp. [91% Base pair (BP) match].
[c]Most closely related to *Debaryomyces* sp. (95% BP match, 5.8s only).
[d]Most closely related to *Calcocera cornea* (80% BP match).
[e]Most closely related to *Phialophora virens* (90% BP match).

Table 4: Fruiting bodies and cultures from Decay Class 4 logs[a]

Cultures	Frequency (# drill holes)	Fruiting bodies
Hypocrea sp.	11	***Antrodia serialis***
unk. Zygomycete D	10	***Coniophora olivaceae***
unk. Ascomycete OO	6	***Fomitopsis pinicola***
Sporothrix sp.	6	***Gyromitra* sp.**
Pesotum sp.	5	***Sistotrema* sp**.
Trichoderma album	5	***Trechispora subsphaerospora***
unk. Zygomycete G	4	***Tubulicrinus* sp.**
unk. Ascomycete DD	4	
unk. Ascomycete KK[b]	3	
unk.Ascomycete NN[c]	3	
Fomitopsis pinicola	3	
unk. Zygomycete A	3	
unk. Zygomycete F	3	
unk. Zygomycete H	3	
unk. Ascomycete C	3	
unk. Ascomycete CC[d]	2	
Cephalosporium sp.	2	
unk. Ascomycete LL[e]	2	
Thysanophora penicilliodes	2	
unk. Zygomycete I	2	
Ampelomyces humuli	1	
unk. Ascomycete AA[f]	1	
Ascocoryne cylichnium	1	
unk. Ascomycete MM[g]	1	
Calcarisporium arbuscula	1	
Leptodontidium elatius	1	
Mortierella sp.	1	
Penicillium minioluteum	1	
Phialophora sp.	1	
Sepedonium sp.	1	
Verticillium fungicola	1	
unk. Zygomycete E	1	

[a] Culture identification based on GenBank search of ITS sequence data. Basidiomycetes shown in boldface.
[b]Most closely related to *Dactylaria* sp. [89% base pair (BP) match].
[c]Most closely related to *Beauveria virella* (83% BP match).
[d]Most closely related to *Calonectria* sp. (91% BP match).
[e]Most closely related to *Sporothrix* sp. (84% BP match).
[f]Most closely related to *Phialocephala virens* (88% BP match).
[g]Most closely related to *Sepedonium chlorinum* (88% BP match).

Literature Cited

Boddy, L. 1983a. Effect of temperature and water potential on growth rate of wood-rotting basidiomycetes. Transactions of the British Mycological Society 80: 141-149.

Czederpiltz, D.L.L., Stenlid, J. 2004. Determining fungal succession in *Picea abies* logs using direct analysis of community rDNA sequences, culturing, and fruiting bodies. Inoculum 55(4): 12.

Gilbertson, R.L., Ryvarden, L. 1986. North American Polypores. Vol. 1. Oslo, Norway: Fungiflora. 433.

Griffin, D.M. 1977. Water potential and wood-decay fungi. Annual Review of Phytopathology 15: 319-329.

Griffith, G.S., Boddy, L. 1991. Fungal decomposition of attached angiosperm twigs. II. Moisture relations of twigs of ash (*Fraxinus excelsior* L.). New Phytology 117: 251-257.

Guglielmo, F., Bergemann, S.E., Gonthier, P., Nicolotti, G., Garbelotto, M. 2007. A multiplex PCR-based method for the detection and early identification of wood rotting fungi in standing trees. Journal of Applied Microbiology 103:1490-1507.

Harmon, M, Fasth, B., Yatskov, M., Sexton, J., Trummer, L. 2005. The fate of dead spruce on the Kenai Peninsula: A preliminary report. U.S. Forest Service Technical Report R10-TP-134. 23 pp. (http://www.fs.fed.us/r10/spf/fhp/more_reports/Beetle%20Kill%20Report%20Final.pdf) (accessed December, 2008).

Hurlbert, S.H. 1971. The nonconcept of species diversity: A critique and alternative parameters. Ecology 52:577-586.

Larsen, M.J.; Harvey, A.E.; Jurgensen, M.F. 1980. Residue decay processes and associated environmental functions in northern Rocky Mountain forests. In: Environmental consequences of timber harvesting in Rocky Mountain coniferous forests. INT-90. Washington, DC: United States Department of Agriculture, Forest Service: 157-174.

Lindner, D.L., Allmer, J., Banik, M., Glaeser, J., Stenlid, J., Trummer, L., Vasiliauskas, R. 2006. Community analysis of wood-inhabiting fungi using fruiting bodies, culturing and rDNA. Abstract, 8th International Mycological Congress, Cairns, Australia. (http://www.ima-mycology.org/doc/Book_1.pdf). (Accessed Jan. 7, 2009).

Lindner, D.L., Banik, M.T. 2009. Effects of cloning and root-tip size on observations of fungal ITS sequences from *Picea glauca* roots. Mycologia 101(1): 157-165.

Loman, A.A. 1962. The influence of temperature on the location and development of decay fungi in lodgepole pine logging slash. Canadian Journal of Botany 40: 1545-1559.

Loman, A.A. 1965. The lethal effect of periodic high temperatures on certain lodgepole pine slash decaying basidiomycetes. Canadian Journal of Botany 43: 334-338.

Lowell, E.C., Willits, S.A. 1998. Lumber recovery from beetle-killed spruce trees, Kenai Peninsula, Alaska. Western Journal of Applied Forestry 13: 54-59.

Masur, C., Anderson, R.G., Cromack, K. Jr., Williams, J.T., Martin, R.E. 1979. Down and dead woody material. In: Thomas, Jack Ward (tech ed). Wildlife habitats in managed forests: the Blue Mountains of Oregon and Washington. Agric. Handb. 553. Washington DC: U.S. Department of Agriculture: 76-95.

National Resources Canada, Canadian Forest Service. 2009. Canadian Wildland Fire Information System. (http://cwfis.cfs.nrcan.gc.ca/en/cwfis_intro_e.php). (Accessed January 10, 2009).

Petty, T.M., Shaw, C.G. 1986. Isolation of *Fomitopsis pinicola* from in-flight bark beetles (Coleoptera: Scolytidae). Canadian Journal of Botany 64: 1507-1509.

Rayner, A.D.M. 1985. Water and the origins of decay in trees. In: Ayres, P.G. and Boddy, L. eds. Water, fungi and plants. New York: Cambridge University Press: 321-341.

Ross, D.W., Daterman, G.E., Boughton, J.L., Quigley, T.M. 2001. Forest health restoration in South-central Alaska: a problem analysis. Gen. Tech. Rep. PNW-GTR-523. Portland, OR:USDA Forest Service. Pacific Northwest Research Station. 38 p.

Sanders, H.L. 1968. Marine benthic diversity: a comparative study. American Naturlist 102:243-282.

Schmidt, O.2006. Wood and Tree Fungi: Biology, Damage, Protection, and Use. New York: Springer. 334.

Sollins, P. 1982. Input and decay of coarse woody debris in coniferous stands in western Oregon and Washington. Canadian Journal of Forest Research 12:18-28.

Spaulding, P. 1929. Decay of slash of northern white pine in southern New England. Techn. Bull. No. 132, Washington, D.C.: U.S. Department of Agriculture. Pp 1-20.

Spaulding, P. 1944. Decay of logging slash in the Northeast. Techn. Bull. No. 876, Washington, D.C.: U.S. Department of Agriculture. 1-21.

Treska, F., Cromack, K. Jr. 1980. The role of wood debris in forests and streams. In: Forests: fresh perspectives from ecosystem analysis. Proceedings of the 40th Annual Biology Colloquium. Corvallis, OR: Oregon State University Press. P 171-190.

USDA Forest Service; State of Alaska DNR. 2003. Forest Health Protection Report: Forest Insect and Disease Conditions in Alaska – 2002. Compiled by Wittwer, D. USDA Forest Service, Alaska Region, Gen. Technical Report R10-TP-113. 62 p.

USDA Forest Service; State of Alaska DNR. 2008. Forest Health Conditions in Alaska – 2007. Compiled by Snyder, C., Schultz, M.E. and Lundquist, J. USDA Forest Service, Alaska Region, Protection Report R10-PR-18. 96 p.

Vasiliauskas, R., V. Lygis, K.-H. Larsson and J. Stenlid. 2005. Airborne fungal colonisation of coarse woody debris in North Temperate *Picea abies* forest: impact of season and local spatial scale. Mycological Research 109: 487-496.

Nursery Pathology Committee Report
Chair: Katy M. Mallams

October 27, 2008 -- 1:00 to 5:00

The annual meeting of the WIFDWC Nursery Pathology Committee was held on the afternoon of October 27th. Ten people attended. Highlights of the discussion included:

1) The effect on the forest nursery industry of proposed new EPA regulations that will severely limit use of any and all fumigants beginning in 2010.

2) The proposal to update Forest Insect and Disease Leaflet (FIDL) #157, Nursery Diseases of Western Conifers. The consensus was that it would be more useful to update Agriculture Handbook #680, Forest Nursery Pests as an on-line publication with stand-alone pages in .pdf format for each insect pest and disease that can be printed individually. The first step will be to pursue funding and a home for the website. Then which of the insect pests and diseases to revise, add or drop will need to be selected, and authors found.

3) How Region 1 Forest Health Protection (FHP) will handle requests for nursery pathology assistance now that Bob James has retired. This led to a discussion of the role of the US Forest Service Western Nursery Specialist position, currently based in Region Six. The group agreed that the position could be more proactive in advocating for and coordinating research and extension work related to forest nursery pathology. There are pressing issues facing the forest nursery industry such as the loss of fumigants, new and emerging pathogens, and interest in growing native shrub and hardwood species about which little is known. The group decided to propose that the WIFDWC Chair write a letter to the FHP Washington Office expressing support for the Western Nursery Specialist position, and encouraging it to have an active role in support of nursery pathology research and expertise within the Forest Service and at universities.

Foliage and Twig Disease Committee Report
Chair: Harry Kope

October 28, 2008 – 07:00 to 08:30 am

A light breakfast accompanied the meeting, which was attended by more than 35 people. Doors opened and the first half hour was spent in general conversation.

The meeting opened with Harry Kope welcoming everyone and setting the stage for this new committee.

David Shaw, Director of the Swiss Needle Cast Cooperative (SNCC), gave an update on the cooperative and work to date. He also explained the membership within the cooperative which, is comprised of private, state and federal organizations. David explained and expanded on other functions and objectives of the cooperative. The objectives are:

1) To understand the epidemiology of Swiss needle cast and the basic biology of the causal fungus, *Phaeocryptopus gaeumannii*;

2) To design silvicultural treatments and regimes to maximize Douglas-fir productivity and ameliorate disease problems in the Coast Range of Oregon and Washington;

3) To understand the growth structure and morphology of the Douglas-fir trees and stands as a foundation for the enhancing productivity and detecting and combating various diseases of Douglas-fir in the Coast Range or Oregon and Washington.

Dr Bill Jacobi, of Colorado State University, presented some preliminary findings on Black Walnut decline in Colorado. A beetle associated with the fungus *Geosmithia* are thought to be the cause of cankers on the branches of walnut trees. There appears to be some range expansion of the beetle from areas south of Colorado. Drought stress could be an initial stressor of walnut trees.
Dr Jacobi also discussed aspen bark beetle with an associated fungus (unknown at this time) that is causing main stem death/deterioration of aspen.

Dr. Jim Walla, of North Dakota State University, presented information on *Stigmina lautii*, which has been found on spruce in eastern and central North America. Jim felt that this species is filling a similar niche as Rhizosphaera needlecast, and appears to have mostly replaced *Rhizosphaera* in North Dakota. Proof of pathogenicity of *Stigmina* is lacking, so it could be a pathogen, an endophyte, or a mycoparasite, but appearances are of a pathogen. Black fruiting bodies fill the stomata of the needles. Needles become necrotic in the second growing season.

Dr Harry Kope of the British Columbia Ministry of Forests and Range presented some preliminary data on *Septoria musiva*, a poplar disease introduced from eastern North America into BC. The pathogen was detected and identified in 2006 and was found to be causing stem cankers at multiple clonal poplar sites. Because of this recent find in BC certain questions need to be answered. How far has the disease spread; can the disease infect native species of *Populus trichocarpa*; can the disease be eradicated? To determine whether the disease has spread to *P. trichocarpa* and if so how far the disease has spread, leaf samples have been collected from over 400 *P. trichocarpa* trees along the Fraser river corridor and around positive finds on colonal poplar sites. The leaf samples are being processed at UBC under the supervision of Dr. Richard Hamelin.

Dr Glen Stanoz of the University of Wisconsin presented information on *Diplodia* on Spruce.

Root Disease Committee Report
Chair: Brennan Ferguson

October 28, 2008 - 12:00 to 1:30 pm

The Root Disease Committee luncheon in Missoula was well-attended by approximately 40 people. The theme for the meeting was stump treatment for annosus root disease.

We started out with a guest speaker, Dick Karsky, a mechanical engineer and Program Leader at the Missoula Technology and Development Center. Dick provided commentary on a video of an automated borax applicator that he helped to design in the 1990s. The applicator system was designed to be mounted on a feller-buncher and allows the operator to position the spray attachment over a stump immediately after cutting in order to apply a calibrated dose of liquid-suspension borax to the stump. Although this system did not see operational use in the northern Rocky Mountains, it was used for a time in the southeastern United States. Further discussion ensued on the logistics and methodology of borax application to stumps.

As part of the discussion on borax treatments, it was announced that a new borax product, Cellu-Treat, is registered for stump treatments and available in at least in a few states in the Midwest and Southeast. Cellu-Treat is a liquid-suspension product suitable for application with a hand sprayer or harvester-mounted applicator. The powdered form of borax registered for stump treatments, known as Sporax, is also still available.

Finally, reports were provided at the province, state, and federal level regarding the current status of stump treatments for annosus root disease in the western United States and Canada. Summaries are provided below.

British Columbia

(Provided by Alex Woods and Stefan Zeglen)

There is no requirement to use borax to treat stumps in British Columbia. In fact, since the company decided not to reregister borax for use as a forestry treatment, there has been no push to lobby them or to switch to another product. No one appears to see annosum as a big risk, especially since thinning of young hemlock or spruce is almost non-existant here.

Oregon Department of Forestry

(Provided by Alan Kanaskie)

In our Klamath Lake District (southern Oregon) our primary silvicultural treatment is partial cutting and we apply Sporax to all ponderosa pine and true fir stumps in areas where we will continue to grow these species. This includes our "edge" ponderosa pine stands that are growing on the fringes of the juniper types. We also treat stumps in recreation sites when we do tree removals.

In all other parts of the state east of the Cascades we make similar recommendations to private landowners, but of course they don't have to do it. The vast majority of State-owned and managed forest is in northwest Oregon and on the Elliott State Forest near Coos Bay. We do not routinely use stump treatments in these areas, except in a few rare circumstances in developed recreation sites.

There has been some debate about how much Sporax to apply to stumps, but considering that the labor cost is the highest part of the application equation, we cover them thoroughly.

Minimum stump size has varied by project. At present we are in the 12-14" range. On some past sales in true fir we went as low as 10".
Examples of contract language below:

Project No. 4. Sporax Treatment. PURCHASER shall treat all cut white fir trees that have a stump diameter of 12 inches or greater. Treatment consists of clearing the cut surface of sawdust and other debris (including snow) that may obstruct treatment, and applying a thin coating of powdered Sporax to the cut surface and any exposed wood surface. Treatment must be completed within 24 hours of tree felling. Reasonable effort must be made to treat every exposed and available stump adjacent to or in the skid trails. Sporax treatment must include a colored dye product so that full stump coverage is evident to PURCHASER and STATE.

Project No. 4 Sporax Fungicide Application. PURCHASER shall treat all live ponderosa pine and white fir stumps that have a diameter of 14 inches or more. Treatment consists of removing all sawdust and debris (including snow) from the stump surface and applying a thin coat of powdered Sporax to the entire exposed surface. The application coating should be at least 1/8" thick and continuous. Treatment must be completed within 24 hours of the tree being severed from the stump. Reasonable effort must be made to treat every ponderosa pine and white fir stump adjacent to or within skid trails. Sporax treatment must include a colored dye product so that full coverage is evident to PURCHASER and STATE. STATE shall supply the necessary quantity of Sporax and dye to the PURCHASER.

Washington Department of Natural Resources

(Provided by Dan Omdal)

Currently no recommendations for stump treatments in either hemlock forests in western Washington or pine forests in eastern Washington.

Montana Department of Natural Resources & Conservation (Provided by Brennan Ferguson)

Currently no formal requirements for stump treatments, but use of borax is recommended in ponderosa pine stands whenever a forester or landowner can be convinced to do so.

Idaho Department of Lands

(Provided by Brennan Ferguson)

Currently no recommendations for stump treatments in any forest types.

USFS Region 1 (Northern Idaho and Montana) (Provided by Blakey Lockman)

	Ponderosa pine	Other conifers
Bitterroot and Lolo National Forests	All stumps ≥12" diameter.	No current recommendation.
Other national forests in western Montana	All stumps ≥12" diameter; recommended on a project-by-project basis.	No current recommendation.
Eastern Montana	No current recommendation.	No current recommendation.
North Idaho	All stumps ≥12" diameter; recommended on a project-by-project basis.	No current recommendation.

USFS Region 2

South Dakota, Nebraska, Wyoming (Provided by Jim Blodgett - FHP Field Office, Rapid City, South Dakota)

Annosus root disease has not been found in the Black Hills of South Dakota but has been found on the Bessey Ranger District of the Nebraska National Forest. It was first reported in 1964 on jack pine. I have found three new stands of jack pine with annosus root disease, as well as for the first time in Nebraska on ponderosa pine (three stands), and eastern red cedar (one stand).

All 10 stands (including the original four) are in the Bessey Ranger District within a 4 mile radius. The Bessey Ranger District is entirely a planted forest.

Borax is apparently being used in the forest but only on larger stumps as per current recommendations. However, they do not produce many large stumps.

USFA Region 2

Colordao (Provided by Jim Worrall - FHP Field Office, Gunnison, Colorado)

As far as we know, the only place where we have annosus root disease in pine, and the P-type of the pathogen (*H. annosum* sensu stricto) is in plantations on the Nebraska National Forest.

Again, to the best of our knowledge at this time, the only place we have annosus in firs, and the S-type of the pathogen (*H. parviporum*), is within the range of white fir in southern Colorado. It is a pretty important disease in some areas there, and borax has been used in the past, as a precautionary measure. I'm not aware of any current use, but we talk about it when a big project is in the works cutting white fir.

USFS Region 3

Arizona & New Mexico (Provided by Mary Lou Fairweather)

Annosus root disease is found in ponderosa pine forests in the Southwest, but impacts are minimal and stump treatments have not been considered necessary.

USFS Region 4

Southern Idaho & Nevada (Provided by Jim Hoffman - FHP Field Office, Boise, Idaho)

In southern Idaho, we do not recommend borax treatment for annosus prevention. The fungus is present in our dry, ponderosa pine sites in southwestern Idaho, and we do see occasional mortality of natural and (or) planted pine seedlings, or even saplings, that grow within about 5 feet of large ($\geq$ 20") ponderosa pine stumps. In old plantation areas, especially in overstocked stands during drought periods, infrequent mortality from annosus root disease is still occurring after 40-years, but is attributed mostly to *Ips pini*.

We don't recommend borax for the following reasons: 1) due to the demise of the timber program in southern Idaho there is very little need for replanting; 2) partial or shelterwood cutting techniques that provide natural regeneration, and avoid the expenses of site preparation and planting, are the preferred harvest techniques when allowed; 3) line officers are concerned for the safety of borax applicators; 4) the expenses of preparing pesticide-

use applications and reports, and applying the borax, are far more than the prevention benefits, especially when our timber volumes are already low due to the bark beetle prevention requirements of widely spaced stands in southwestern Idaho; 5) *H. annosum* occurrence is widespread in southwestern Idaho and readily kills and resides in the roots of bitterbrush and chokecherry in addition to pines. What good is it to put borax on pine stumps when it is infecting several other plant species?

USFS Region 4

Utah (Provided by John Guyon - FHP Field Office, Ogden, Utah)

To my knowledge we don't do any stump treatments with borax.

USFS Region 5

California (Provided by Pete Angwin)

Here's the guidance on stump treatments that we have:

1. USFS Manual 2303.14 (R5 Supplement 2300-92-1) stipulates that all freshly cut coniferous tree stumps in and around developed recreation sites be treated. In the USFS Handbook, R5 Supplement 3409.11-94-1, this is clarified to include "other high value areas, such as progeny test sites, seed orchards and areas of high value trees, such as giant sequoia groves."

2. USFS Handbook, R5 Supplement 3409.11-94-1 also recommends the following:

In eastside pine or mixed conifer type stands, where surveys have indicated high levels of annosus root disease, treatment of conifer stumps 12 inches or greater in diameter is highly recommended during chainsaw felling. When mechanical shearers are used, the minimum diameter should be reduced to 8 inches. These areas include the eastside pine and eastside mixed conifer types on the Modoc, Lassen, Plumas, Tahoe, Sequoia and Inyo National Forests; the Goosenest Ranger District, Klamath National Forest; and the McCloud Ranger District, Shasta-Trinity National Forests.

In all other areas, consider stump treatments on an individual stand basis. The line officer is responsible for the decision to treat freshly cut conifer stumps, and shall base that decision on information available for the specific situation in the particular stand in question.

3. However, in response to more recent research and survey data generated, in part, by John Kliejunas, we now recommend in east-side pine or mixed conifer situations, treating conifer stumps 14 inches and larger, rather than the 8 or 12-inch sizes above. West-side situations remain at the line officer's discretion, in consultation with FHP personnel. Where the recommendation is to treat, we now generally recommend 14 inches and larger. We are currently working on changing the handbook language to include this new information.

USFS Region 6 (Oregon & Washington) (Compiled by Greg Filip)

	Ponderosa pine	White/Grand fir	Nobel/Pacific silver/Shasta red fir	Subalpine fir	Mountain hemlock	Western hemlock
Northeast OR and SE Washington (C Schmitt)	On dry/poor sites, treat stumps ≥ 14" diameter.	Where fir is managed, treat stumps ≥ 14" diameter.	Not present.	Treat stumps ≥ 12" diameter.	Not present.	Not present.
Central OR (K Chadwick)	On dry/poor sites, treat stumps ≥ 14" diameter.	Where fir is managed, treat stumps ≥ 16" diameter. No treatment in mixed stands.	Where fir is managed, treat stumps ≥ 16" diameter. No treatment in mixed stands.	No current recommenda-tion.	Treat stumps in developed recreation sites.	Not present.
Westside OR and WA (D Hildebrand)	No current recommenda-tion.	Where true fir is important as a stand or recreation site component, treat stumps ≥ 12" diameter.	No current recommenda-tion.	Where true fir is important as a stand or recreation site component, treat stumps ≥ 12" diameter.	No current recommenda-tion.	No current recommenda-tion.
Southwest OR (D Goheen)	No current recommenda-tion.	Where fir is managed, treat stumps ≥ 12" diameter.	Where fir is managed, treat stumps ≥ 12" diameter.	Treat stumps ≥ 12" diameter in developed recreation sites.	Treat stumps ≥ 12" diameter in developed recreation sites.	Treat stumps ≥ 12" diameter in developed recreation sites.
Western WA (J Hadfield)	No current recommenda-tion.	Treat only in stands with no previous harvests.	Treat only in stands with no previous harvests.	No current recommenda-tion.	Treat only in developed recreation sites with no previous cuts.	No treatment recommen-ded.

Hazard Tree Committee Meeting
Chair: Pete Angwin

October 29, 2008 -- 7:00 to 8:20 am

24 people attended the WIFDWC Hazard Tree Committee Breakfast. Five items were on the formal agenda:

1) Pete Angwin led a discussion on the 2010 Hazard Tree Workshop. Suggestions for the Workshop location are still being solicited. Minneapolis/St. Paul and somewhere in Region 6 have been suggested as potential locations. A planning committee meeting will be held in the spring of 2009 to finalize the location and discuss field trip and presentation/panel topics. **Participation in the planning committee is encouraged- call or e-mail Pete if you'd like to be part of the committee (phone 530-226-2436 or e-mail pangwin@fs.fed.us).**

2) Lori Trummer led a discussion on the National Hazard Tree Coordination Initiative. With Lori's pending retirement, Jim Worrall is now leading this initiative, which seeks greater National coordination in Hazard Tree policies and programs. Jim's phone number is 970-642-1166 and e-mail is jworrall@fs.fed.us. National Coordination Initiative committee members are Jim Worrall (Region 2), Bruce Moltzan (WO), Joe O'Brien and Jill Pokorny (Northeastern Area), Bill Jones (Region 8), Pete Angwin (Region 5), Greg Filip (Region 6) and Judy Adams (FHTET).

Two items of the draft initiative that was discussed at last year's Hazard Tree Committee Meeting have made significant progress. The National Hazard Tree Web Site is soon to be on line, and Bruce Moltzan has been hired as the new national FHP pathologist in the USDA Forest Service Washington Office. Among his responsibilities is the coordination of national hazard tree issues. In addition, the draft initiative was discussed with Rob Mangold (FHP National Director) and met with his general approval.

Bruce Moltzan introduced himself and continued the discussion. He confirmed that serving as point person for national hazard tree issues is one of his responsibilities, and that he welcomes the participation of the WIFDWC Hazard Tree Committee. He reported that Rob Mangold has discussed the draft HT Initiative with the other FHP Directors and confirmed that this was something they were concerned about. They felt, among other things, that a proactive approach may help prevent hazard tree-related accidents and reduce agency liability. Bruce also discussed the need to engage other agencies (i.e., National Park Service, BIA and BLM) and other staff areas of the Forest Service (fire, recreation and engineering) in this effort.

3) Judy Adams next led a discussion on the National Hazard Tree Web Site and the International Hazard Tree Failure Database (ITFD). The structure for the National Hazard Tree Web Site has been completed and a handout showing the web site's home page was distributed. A link to the ITFD is included, and a section on the WO's mission with regard to hazard tree management may also be included. While the web site serves as a clearinghouse for national hazard tree information, links are included to each Region's hazard tree web site. Each Region are encouraged to put hazard tree reports, Regional hazard tree evaluation forms and training materials (.pdf's, powerpoint presentations, etc.) in their section.

Discussion of the ITFD included several issues. Bill Jones (Region 8) currently chairs the ITFD Steering Committee, but may propose that the chair be rotated among committee members. There is a continuing need to encourage greater use of and data input into the ITFD. To address these needs, the data entry process is currently being restructured to make it easier for users to enter data and generate reports. Efforts are underway to get funds to the ISA to assist with ITFD training and data input. Generally, most reports have involved failures that have had associated property damage. Reports on failures that have not hit anything, and data on trees that do not fail are also needed.

4) Brennan Fergusen led a discussion on the update of the Forest Insect and Disease Leaflets (FIDLs). Kathy Sheehan (Region 6) is the national FIDL

coordinator, and each region now has a contact. The Regional contacts are named and listed in the new FIDL web page (http://www.fs.fed.us/r6/nr/fid/wofidls/index.shtml), which also has .pdf files of all of the FIDL's and information on the FIDL update effort.

Twelve pathology FIDLs are currently being updated, and seven are for decay organisms. Some have already been finished. A flash drive containing all of the current FIDLs was distributed to all of the WIFDWC attendees.

5) Greg Filip next led a discussion on the Region 6 Danger Tree Program. A new Regional Danger Tree Identification Field Guide is available from Greg and on line at:

http://www.fs.fed.us/r6/nr/fp/ReserveTree05/FieldGuideforDangerTreeIdentification&Response.pdf

The engineering staff groups in the Washington Office and Region 6 are currently developing a national roadside danger tree policy and have solicited our help to make the program work. Funding for roadside danger tree assessments has been a huge issue. The R6 Danger Tree Guide helps by providing an assessment prioritization protocol. Funding was initially just for lands along federal roads, but state roads are a huge issue that is not being addressed. Support is now coming from the fire program area since several fires have burned down to roads. In 2008, Region 6 had approx. 200 miles of roads affected in this way.

After the discussions on the five formal agenda items, two additional items were discussed:

1) Jim Hoffman reported on a mountain pine beetle outbreak in the SNRA that is creating hazard tree problems. Many of the healthy trees that had been sprayed to protect them from the beetle blew down because they had larger crowns and were more exposed to wind. Work with FHP staff entomologists is needed to avoid this issue in the future.

2) Sue Hagle reported on a hazard tree evaluation she did at a Wilderness Area airstrip. Because of blowdown concerns, all facilities need to be removed, but treatment can't be done because of restrictions on the use of chainsaws in Wilderness Areas. Because these areas can't always be treated, an educational program is needed to encourage folks to use areas that are safer.

Root Disease Stop on Field Trip

Rust Committee Meeting
Chair: Holly Kearns

October 30, 2008 – 7:00 to 8:30 am

Twenty-two people attended the Rust Committee breakfast meeting on October 30, 2008. Several reports on recent, current, and pending activities were given. The following is a brief recap of the projects discussed, for details contact the person listed.

Michelle Cleary reported on the very successful Third Western White Pine Management Conference held in Vernon, BC in June 2008, which reached nearly 100 forest practitioners.

Bill Jacobi reported on the pruning of limber and bristlecone pines project. Trees look good but mountain pine beetle in one study site are taking out the limber pines.

Alex Woods reported that incidence of comandra blister rust has increased in British Columbia, with 40% of stands rated as high incidence in 2008 compared to 6% of stands with high incidence in 1999.

Kristen Chadwick discussed her work in establishing 60 permanent plots in whitebark pine in central Oregon.

Michael Murray plans to start a white pine blister rust screening program for whitebark pine.

Jim Hoffman reported that he found no *Ribes* or white pine blister rust in limber pines in the Deep Creek Range located near the Nevada-Utah border as of his recent survey.

Brennan Ferguson reported on the results of long-term monitoring in F2 western white pine plantations in northern Idaho for white pine blister rust.

John Schwandt reported several on-going projects including surveys for white pine blister rust and mountain pine beetle in whitebark pine, white pine blister rust canker expansion rates in F2 western white pine, and a new project examining the effects of thinning in whitebark pine.

The wasn't enough time to complete the round robin, which lead to a discussion on holding a longer Rust Committee meeting at the Durango WIFDWC in 2009. The committee agreed that this should be pursued, and the topic was raised at the Business Meeting. The Durango WIFDWC Program Chair and committee are making every effort to accommodate a longer Rust Committee Meeting.

Dwarf Mistletoe Committee Meeting
Chair: Greg Filip

October 31, 2008 -- 7:00 to 8:30am

Contributions from R. Mathiasen to the Dwarf Mistletoe Committee Report. We published a review article on mistletoes in Plant Disease (92:988-1006) which includes information on dwarf mistletoes. This was a feature article titled: Mistletoes: pathology, systematics, ecology, and management and contains over 200 citations on mistletoes from around the world. To obtain a pdf of the paper contact Dave Shaw or Bob Mathiasen. R. Mathiasen, Northern Arizona University, Flagstaff; Dan Nickrent, Southern Illinois University, Carbondale; Dave Shaw, Oregon State University, Corvallis; Dave Watson, Charles Sturt University, Albury, Australia.

Taxonomy, Hosts, and Distribution

Taxonomic Changes and Additions:

Morphological and molecular analyses of *Arceuthobium aureum* and *A. globosum* has demonstrated that these taxa are closely related, but can be distinguished based on a few morphological differences, phenology, and their host ranges. Therefore, the taxa previously treated under *A. aureum* hve been recombined under *A. globosum*: *A. globosum* subsp *aureum* and *A. globosum* subsp. *petersonii*. The geographic distributions of the subspecies of *A. globosum* do not overlap, except subsp. *grandicaule* and subsp. *petersonii* are sympatric in central Chiapas, Mexico. These subspecies can be distinguished by their plant size, width of staminate spikes, and flowering periods. The article recombining A. aureum under A. globosum will be published in Novon, volume 18, issue no. 4, pages 501-507. R. Mathiasen, Northern Arizona University, Flagstaff.

We have started a systematic study of dwarf mistletoes that primarily parasitize white pines in western North America and Mexico. We will use molecular techniques (AFLP analysis) and make additional morphological measurements for *A. apachecum, A. blumeri, A. californicum, A. cyanocarpum, A. monticola,* and *A. guatemalense* over the next three years to better determine that taxonomic relationships of these taxa. B. Reif and R. Mathiasen, Northern Arizona University, Flagstaff.

New Hosts:

Mountain hemlock dwarf mistletoe (*A. tsugense* subsp. *mertensianae*) was found parasitizing sugar pine (*Pinus lambertiana*) for the first time a few km north of Windigo Pass, Oregon. R. Mathiasen, Northern Arizona University, Flagstaff

New Distributions:

Over the last 10 years our studies of dwarf mistletoes in Durango, México have found many new locations for several of the 12 taxa that occur in the state. In particular, the distributions of *A. rubrum* and *A. verticilliflorum* have been expanded considerably within Durango. A paper updating the geographic distribution of *Arceuthobium* in the state will be published in Madroño, volume 44, issue no. 2, pages 161-169. R. Mathiasen, Northern Arizona University, Flagstaff; Socorro González Elizondo, Herbario CIIDIR, Instituto Politécnico Nacional, Durango.

Ecology

We have begun a study of biomass relationships for un-infected and dwarf mistletoe-infected branches of Douglas-fir in northern Arizona. We are also examining branch architecture of Douglas-fir dwarf mistletoe-induced witches' brooms. L. Smith, Northern Arizona University, Flagstaff; R. Mathiasen, Northern Arizona University, Flagstaff; C. Hoffman, University of Idaho, Moscow.

Business Meeting Minutes

Ellen Michaels Goheen

The Business Meeting of the 56th Western International Forest Disease Work Conference was called to order at 12:00 pm October 3, 2008 by Chairman Gregg Denitto.

Old Business

Minutes from the Business Meeting of the 55th WIFDWC held in Sedona, AZ, October 15-19, 2007, were accepted as written.

WIFDWC Chair Gregg Denitto acknowledged the excellent work done by meeting organizers including: Blakey Lockman, Marcus Jackson, Brennan Ferguson, John Schwandt, Holly Kearns, and Amy Gannon for local arrangements and field trip planning, Bill Kramer, Doug Wulff and Nancy Sturdevant for assistance with registration, Nancy Sturdevant, Ken Gibson, and Brytten Steed for assistance with the field trip, John Schwandt for his work as Treasurer, Fred Baker as this year's Secretary, Will Littke for organizing the program, Amy Ramsey for coordinating the poster session, and Judy Adams for her work as webmaster. Gregg also thanked all the local folks on the Lolo and Bitterroot National Forests who helped with the field trips.

The Treasurer's Report is included in these proceedings as a separate document.

At the 2007 meeting the WIFDWC Chair was directed to write a letter to the Chief of the Forest Service and the Director of Forest Health Protection, USDA Forest Service, Washington DC requesting that the Washington DC office fill the vacant position of national plant pathologist as soon as possible and that the duties of the position include coordination of hazard tree issues nationwide, coordination of introduced diseases and climate change issues. That letter was written by Stefan Zeglan (*signed by the Queen*) and sent. Bruce Moltzan was hired in July, 2008 to fill that position. He is currently working to coordinate hazard tree issues nationwide and has been assigned work with introduced pathogens including *Phytophthora ramorum*, and climate change.

At the 2006 meeting, Bill Jacobi and others were assigned the task of looking at how publishing work in proceedings such as those produced by WIFDWC influences a pathologist's ability to publish in peer-reviewed journals. Bill reported to the group that editors of scientific journals do not usually care if authors have published in conference proceedings and that conference proceedings do not compete with peer-reviewed journals. He suggested that if WIFDWC members were concerned, they limit their WIFDWC contributions to abstracts or extended abstracts and limit the amount and detail of data published in the WIFDWC proceedings.

In 2006 a committee was formed (composed of Blakey Lockman, Holly Kearns, John Schwandt, and Bob Edmonds) to look at how WIFDWC could generate funds that would then be used to provide travel/meeting attendance assistance to graduate students. Blakey and Holly reported at this meeting that little progress had been made thus far on this issue. A motion was put forward by Blakey that if the committee, working with the executive committee/local arrangements group for the 2009 meeting, comes up with a viable idea for generating such funds WIFDWC would approve it as a pilot project. The motion was seconded. Discussion was held about how other organizations accomplish this, such as APS and its APS Foundation and Northwest Science Association and its research fund. Members were reminded that our bylaws state that students will have a discounted registration fee when they attend our meetings. The motion passed.

Committee Reports

An ad hoc committee on **Foliar and Twig Diseases** with Harry Kope as Chair was formed at the 2007 meeting. Harry reported that the committee had a breakfast meeting this year that was well attended with several excellent presentations and much good discussion.

An ad hoc committee on **Climate Change** with Susan Frankel and Terry Shaw as Co-Chairs was formed at the 2007 meeting. The committee met and held a discussion on goals and objectives. The stated

goal of this committee is to promote forest pathology in climate change science. Dave Shaw agreed to work with Susan on this issue.

Hazard Tree Committee: Chair Pete Angwin reported that the committee has a tradition of organizing and holding a Hazard Tree Workshop every three years. The next workshop will be held in 2010. No location has been settled on as yet.

Nursery Pathology Committee: Chair Katy Mallams reported that the committee discussed updating nursery pathology publications at their meeting. Rather than revising FIDL 157, there is much more interest in revising and updating AG Handbook 680 Nursery Pests and having that available online. AG Handbook 680 is national in scope and includes insect pests of nursery crops. Katy will be investigating potential ways to accomplish the work, identify funding sources, and will be looking for volunteers to revise chapters.

The Nursery Committee also discussed loss of nursery pathology expertise in the West now that Bob James has retired and the USDA Forest Service western nursery specialist position (vice Tom Landis) remains unfilled. Katy made a motion that WIFDWC send a letter to the Washington DC office of the USDA Forest Service requesting that the western nursery specialist position be filled as soon as possible and stating the importance of the person in that position supporting nursery pathology research and extension. The nomination was seconded. There was no further discussion and the motion passed. Katy will draft the letter for executive committee review.

Root Disease Committee: the root disease committee focused its discussion on status, information needs, and stump treatment associated with *Heterobasidion annosum*. Representatives from various western regions and Provinces reported on their stump treatment practices and policies. Dick Karsky of the USFS Missoula Technology Development Center showed a video on the borax application system that can be attached to mechanical harvesters. The meeting attendees were made aware of new availability of Timbor®, registered now in a formulation called CelluTreat®, for stump treatments.

Rust Committee: Chair Holly Kearns reported that the rust committee meeting was well attended with excellent discussion. She is hoping to organize a longer meeting (perhaps 3–4 hours) during the 2009 WIFDWC.

Dwarf Mistletoe Committee: There was no report from the Dwarf Mistletoe Committee during the business meeting.

New Business

Nominations for 2009 Officers: Alan Kanaskie, spokesman for the nominating committee, nominated Greg Filip to serve as Chairman and Judy Adams to serve as Secretary for the 57th WIFDWC. Nominations were closed. The proposed slate of officers was elected unanimously.

A motion was made and seconded to have John Schwandt continue as WIFDWC Treasurer. The motion passed.

Chairman Gregg Denitto brought to membership attention that Duncan Morrison, who had been the WIFDWC historian was now officially retired and a new historian was needed. Rona Sturrock reported that Duncan had "unofficially" turned over his records to her. A motion was made and seconded to elect Rona Sturrock to the position of WIFDWC historian. The motion passed.

2009 WIFDWC: Bill Jacobi reported that the 2009 WIFDWC will be held in the Durango, Colorado area in July 2009. He promised that the meeting dates would not conflict with the APS meeting in Portland, Oregon Aug 1-5. Members were polled as to preference for a downtown Durango meeting location versus a nearby ski resort; WIFDWC members preferred holding the meeting downtown. The local arrangements committee will proceed accordingly.

2010 WIFDWC: Michelle Cleary reported that a venue has been selected for the 2010 WIFDWC in Valemount, BC. The meeting will be held the first week of October to avoid the type of fire budget/travel difficulties US agency personnel faced in 2008. Valemount is approximately 300 km from Prince George or Kamloops.

2011 WIFDWC: Chair Gregg Denitto asked for volunteers to host the 2011 meeting. Greg Filip invited the members to central Washington; either the

Leavenworth or Lake Chelan areas. No other offers were made. A motion was made and seconded to meet in central Washington in 2011. The motion passed.

Foliage and Twig Disease Committee: Harry Kope made a motion that the ad hoc Foliage and Twig Committee be made a standing committee. Discussion ensued. Creating a new standing committee requires a change to the bylaws. A change to the bylaws requires that all WIFDWC members be notified of the proposed change and that the change be approved by 2/3 majority vote queried at a business meeting. Harry withdrew his motion. The Secretary will send an email message to the membership with the proposal to create a Foliage and Twig Disease Committee. A vote on that proposal will take place at the Business meeting in 2009.

Outstanding Bill for Proceedings CDs: John Schwandt alerted the members that WIFDWC still owes Utah State University $4,000 for scanning and producing the collection of WIFDWC Proceedings on CDs. He made a motion to pay the outstanding bill from our account balance, thereby stopping any additional registration fees associated with paying off the CDs. The motion was seconded and passed.

In **further discussions regarding WIFDWC proceedings**, Sue Hagle made a motion that the WIFDWC proceedings be made available electronically on the WIFDWC website. The motion was seconded and passed. Bill Jacobi moved that we remove the frontpiece from our proceedings which states "these proceedings are not available for citation of publication without consent of the authors". The motion was seconded and passed.

The **Outstanding Achievement Award Committee** currently consists of Brennan Ferguson, Richard Reich, and Ellen Goheen. Brennan will rotate off the committee as of the 2008 meeting and Richard will become Chair. Nominations were opened for a third committee member. A motion was made and seconded for Pete Angwin to serve on the committee. Nominations were closed. The motion passed.

No new Honorary Life Members were recognized in 2008.

The meeting was adjourned at 1:00pm.

Business Meeting Action Item

Mr. Ted Beauvais, Acting Director
Forest Service, U.S. Department of Agriculture
Cooperative Forestry Program
State and Private Forestry
Sidney R. Yates Federal Building
201 14th Street SW
Washington, D.C. 20024

December 11, 2008

Dear Mr. Beauvais,

Forest Service personnel in the western U.S. devoted to forest nurseries and nursery pathology have undergone significant changes recently. Many long-time employees have retired, including Dr. Tom Landis, formerly the Western Nursery Specialist. Dr. Landis provided technology development and transfer, consultation, advice, and leadership on issues critical to forest nurseries in the western U.S. and nationally. He worked closely with forest pathologists in the western U.S. to find solutions to disease problems and provide educational materials to the forest nursery industry. After his retirement, the position was temporarily filled, but is now vacant again.

The Western Forest International Forest Disease Work Conference (WIFDWC) is the professional organization of government, university and private industrial forest pathologists in Western North America. Our members are involved in technical assistance, research and education in forest pathology. WIFDWC is very concerned about this loss of expertise and leadership in nursery science within the U.S. Forest Service. There are pressing issues that face the forest nursery industry today including the loss of fumigants, new and invasive pathogens, and interest in growing new crops for restoration about which little disease information is known. Funding for research and education has declined within both Forest Service and universities.

On behalf of our members, I would like to encourage you to support filling the Western Nursery Specialist position as soon as possible. Ideally, the person who fills the position would have a strong background in nursery pathology. This would let them be an advocate for forest nursery pathology research and expertise within government agencies and universities, and work closely with forest pathologists in the West to respond to the challenges facing the forest nursery industry today.
Sincerely,

/s/ Gregg DeNitto

Gregg DeNitto, Chair
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USDA Forest Service Forest Health Protection
Missoula Field Office
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Institutional / Regional Reports

News from UBC.

Dr. Richard Hamelin is the new forest Pathologist in the Department of Forest Sciences at UBC. Richard has been at UBC on sabbatical (from the CFS Laurentian Lab) and teaching the Forest Pathology courses for the last two years. Recently the University signed a 5-year Memorandum of Understanding with the Canadian Forestry Service that will allow Richard to continue to work at UBC while he remains a CFS employee. Richard will also continue to lead his research group at the CFS Laurentian Lab in Quebec.

Currently Richard is involved in the following projects at UBC.

One M. Sc. Student (Simren Brar) will be working on C. ribicola population genetics. She will be conducting a population genetic study of C. ribicola in White Bark Pine and comparing genetic diversity in the high elevation and low elevation pines (P. monticola). Her DNA markers will also let her know if she encounters the C. ribicola-C. comandra hybrids. If so, the distribution and occurrence will be recorded.

One Post-Doc (Clement Tsui) working on the Genomics of the Mountain Pine Beetle epidemics. He has worked on exploiting genomics resources from Ophiostoma clavigerum, a fungal associate of the MPB to develop microsatellite markers to better understand the pathogen's genetic variability and provide insights into the origin and patterns of spread of the epidemic, and the mode of reproduction. So far, he found that the two most northern populations had lower genetic diversity than the southern populations. He found over one hundred unique haplotypes and observed clonal lineages only rarely. This was surprising since the sexual fruiting bodies are rarely discovered.

To determine whether the fungus is heterothallic he searched the genome for genes homologous to the mating type idiomorphs MAT1-1 and MAT1-2. He found a gene (with HMG domain) that was homologous to the MAT1-2 idiomorph. He amplified that gene in the *G. clavigera* strains and found that there was a 1:1 ratio for the presence of HMG domain and a null allele in the population. This suggests that the fungus may reproduce sexually and may be heterothallic.

One post-doc (Nicolas Feau) is working on Septoria musiva in B.C. Use of hybrid poplar in north-central and northeastern North America is limited by occurrence of the leaf spot and canker disease caused by Septoria musiva (teleomorph Mycosphaerella populorum). Nicolas has previously conducted molecular marker analyses to document the occurrence of genetically differentiated S. musiva subpopulations, with both asexual and sexual reproduction contributing to the local level of genetic structure. With the increase in poplar cultivation, stem cankers have recently been reported in new bioclimatic domains in the province of Québec and in the Fraser valley in British Columbia previously considered to be S. musiva-free. High genetic and genotypic diversities were also found in these populations indicating that a recent population bottleneck is unlikely. Nicolas proposes two explanations for this observation: 1) the disease has been established, but not detected, for a long time in these regions, or 2) multiple introductions from a diverse source occurred. A precise knowledge of the geographical and host range of S. musiva is now required for evaluating risk of damage of this plant pathogen in these newly infected areas. A survey based on a DNA barcoding system is currently used to determine the level of occurrence of the exotic S. musiva on native (P. trichocarpa) and hybrid poplars in BC relative to the indigenous species S. populicola and to evaluate risk of damage associated with the extension of this fungus in this area. One French coop student and one UBC undergrad are working with Nicolas on this. (Submitted by Bart Van Der Kamp

USDA Forest Service, Region 6, FHP

The following is an annual report from the regional office and five service centers for our 2008 pathology activities:

Regional Office, Portland, OR (Submitted by Greg Filip)

- Coordinated writing and printing of a revised guide: *Field Guide for Danger Tree Identification and Response*
- Writing two FIDLs on Indian paint fungus and Schweinitzii root and butt rot
- Coordinating the writing of a *Field Guide to the Common Diseases and Insect Pests of Oregon and Washington Hardwoods*
- Coordinated two workshops on danger trees in 2008 and planning new workshops for 2009.
- Acted as western-regional forest-health-monitoring coordinator for 4 months
- Assumed invasive disease duties from entomologist Dave Bridgwater who retired this year.
- On Sept. 30-Oct 1, helped to conduct a workshop on *Silvicultural Treatments and Major Insect and Disease Pests on Indian Lands* in Spokane, WA in coordination with Region 1 and Oregon State University.

Wenatchee Service Center, Wenatchee, WA (Submitted by Angel Saavedra)

- Conducted several evaluations of diseases for Ranger Districts, Indian Reservations, BLM, National parks.
- Conducted insects and disease assessments in fuel reduction planning areas for NPS, BLM and National Forests.
- Conducted study examining insect and disease occurrence that occur within the first year of ponderosa pine and Douglas-fir being killed by wildfire.
- Participated as speakers at a workshop on *Silvicultural Treatments and Major Insect and Disease Pests on Indian Lands* in Spokane, WA.
- Conducted an assessment of conifer foliage browning apparently associated with highway de-icer applications.
- Hope to host WIFDWC in 2011

Westside Service Center, Sandy, OR

(Submitted by Diane Hildebrand)

- Arranged and hosted a workshop on danger-tree identification and response at the HJ Andrews Experimental Forest for Westside of Region 6.
- Served a 30-day detail to Region 2 in July-Aug. and drafted a Guide to Revegetation of Campgrounds after Bark Beetle Mortality. Diane will return in late Oct. to finish the guide and other projects. Beginning in Oct. Kris Chadwick from Central Or Service Center will be on detail at Sandy for 120 days to cover for Diane and gain Westside experience.
- Attempting to culture from *Bridgeoporus nobilissimus* conks collected from Salem BLM lands, possibly developing the capability of inoculating trees with it. The fungus is considered rare and a species that requires special protection (survey and manage under the NW Forest Plan)

Blue Mountains Pest Management Service Center, La Grande, OR (Submitted by Craig Schmitt)

- The Blue Mountains Service Center was the first of five established in Region 6 and will mark its 20-year anniversary this year.
- Over the 20-year period, the pathology work has changed and remains a challenge
- Principal work includes: roadside danger-tree review, campground hazard-tree evaluations, district crew and regional training, writing tree mortality guidelines, developing and validating fire-mortality-rating systems, proposed project reviews, and forest-plan revision including risk rating and hrv analysis
- Monitoring juniper inoculations with *Heterobasidion annosum* with the goal of reducing juniper through tree mortality.

Central Oregon Insect and Disease Service Center, Bend, OR (Submitted by Kris Chadwick)

- Arranged and hosted a workshop on danger-tree identification and response for Eastside of Region 6 in Bend and Sisters, OR.
- Hosted an advanced insect and disease workshop for recertification of USFS silviculturists in Klamath falls, OR
- Aaron Smith has been working with the Rocky Mountain Research Station to assess Armillaria species composition and develop a risk map by vegetation type in the Oregon eastside Cascades.
- Helen Maffei has been working on validating hazard-rating systems for insect and diseases using mapped spatial data and aerial survey.
- Kristen Chadwick has been coordinating a project to install whitebark pine monitoring plots east in eastern Oregon and Washington. She is also heading up a project to install interpretative signs for whitebark pine on Mt. Bachelor, Crater Lake, and Newberry Crater.
- Kristen Chadwick has been collaborating with the Blue Mountain Service Center and the Wenatchee Service center on establishing long-term monitoring plots in subalpine fir stands to monitor trends in mortality and regeneration from balsam woolly adelgid.
- Kristen Chadwick will be on detail at the Westside Service Center in Sandy, OR for 120 days starting Oct. 1. Submittted by Greg Filip

Southwest Oregon Forest Insect and Disease Service Center, Central Point, OR (Submitted by Ellen Goheen)

- Conducted several interagency (BLM and USFS) training sessions including identifying hazard trees in developed recreation sites and disease and insect identification, biology, and management.
- Participated in a workshop on danger-tree identification and response at the HJ Andrews Experimental Forest for Westside of Region 6. Monitored danger tree treatments and tree failure sites.
- Provide nursery pathology and entomology expertise and training for J Herbert Stone Nursery, Sprague Seed Orchard, and Dorena Genetics Resource Center. Ongoing projects include *Phytophthora* species spread, impacts, identification, and management, spread and impacts of *Fusarium* species on seed and seedlings, and root weevil monitoring.
- Provide leadership and management for the Port-Orford-cedar program on USFS lands in California and Oregon. Conducted first mapping of POC and POC root disease on the Siuslaw NF; expect complete consistent mapping of POC and POC root disease on all USFS lands in CA and OR by end of 2009. Evaluating impacts of the 2002 Biscuit Fire on *Phytophthora lateralis* survival. Monitoring and evaluating roadside sanitation treatments.
- Provide USFS leadership for Sudden Oak Death in OR. Working with wildlife regulatory agencies to develop strategies for treating SOD in TES habitat on federal lands and on the NEPA appropriate for federal land treatment. Cooperating with ODF, ODA, and OSU on SOD surveys, eradication treatments, monitoring, research, and public education.

Colorado State University Forest and Shade Tree Disease Studies-Fall 2008

(submitted by B. Jacobi, Meg Dudley, Anne Marie Casper and Dan West)

Impacts

1. We are studying the movement of firewood in the state and region to determine the risk of moving insects and pathogens by this pathway. In cooperation with State and Federal agencies we have an active detection and education program on the risk of EAB movement. In a sample of 17 states in the U.S., fifty eight percent of the retail store sold firewood was apparently from outside the state it was being sold in.
2. We found the new exotic banded elm bark beetle can move the Dutch elm disease pathogen to trees and make feeding wounds but we have not been able cause wilting in elms.
3. We are coordinating the National Elm Trial at 16 states.
4. We have completed a study MgCl2 use as a dust suppressant on non-paved roads and found the salt moves up to 20 feet from the road or farther in drainages.

Shade Tree Disease Studies

1. **Water usage by Cottonwoods:** We continue to take data on water potentials and tree health. I still plan to write a summary manuscript on this 10 year study.
2. **$MgCl_2$ study:** Salt used for dust control on gravel roads is common in the west. We find salt moves 0-20 feet away from gravel roads on normal embankments. Drainages allow salt to move away from roadway and stream sampling indicates small amounts of salt move into streams. Trees take up chloride and foliar concentrations are correlated with foliar damage.
3. **Banded Elm Bark Beetle:** The Dutch elm disease pathogen was successfully isolated from the banded elm bark beetle and Plant Disease article is out. Inoculation/vector studies of 2006 and 2007 indicate artificially infested beetles can move the fungus to feeding wounds. We have no infection/disease establishment evidence after two years of trials.
4. **National Elm Trial:** We have 16 states with 17 sites total involved in a trial of 17-19 commercially available elm cultivars. NCR- 193 members and other cooperators are involved.
5. **CAPS:** We repeated a retail firewood survey in Colorado this. Education efforts to reduce firewood movement into the state are making good progress but we need some all-out bans on interstate movement.

Forest Tree Insect/Disease Studies

1. **White Pine Blister Rust:**
   a. A hazard-rating model for WPBR is in the works. Three papers are published, and one on the way.
   b. We are continuing our small-scale meteorological analysis of the risk of blister rust in the Rocky Mts.
   c. We help coordinate white pine health work via the Central Rocky Mountains White Pine Health Working Group.
   d. A demonstration study of pruning of blister rust impacted trees was installed at: Sand Dunes and Medicine Bow NF in cooperation with UDSA Forest Serve. Forest Health Management. A manuscript by Amanda Crump is being rewritten.
   e. A new graduate student will start a study of regeneration issues related to natural regeneration, planting seeds or seedlings.
2. **Trap and Lures for Ponderosa Pine Wood Borers:** One manuscript by Sheryl Costello is published and one will be submitted.
3. **Technology Transfer of Forest Pathology:** Amanda Crump (MS candidate) finished her study on the movement of forest health science based information from researchers to the end users within the USDA, Forest Service. A manuscript is being prepared.
4. **Fire, Dwarf mistletoe and Mt Pine Beetles in Front Range Colorado Ponderosa Pine:** Jennifer Klutsch and Russell Beam (MS candidates) are writing their manuscripts on the study on interactions of these three disturbance agents. They are looking at fuel production, stand structure and fire and relationships between dwarf mistletoe and bark beetles.
5. **Thinning effects on bark beetle attack in California:** Joel Egan completed a MS project in the summer of 2008 comparing beetle mortality in unmanaged stands vs. stands thinned in the last 30 years.
6. **Bark Beetle mortality and future fire risk:** Dan West will complete this MS project over the next year and is gathering data on fire locations and previous beetle outbreaks in Colorado. He spent the

summer doing field assessments of previous beetle infestations and if fires were associated with these areas in the decades since the mortality events.

New Disease Issues

1. Pine wilt nematode did not kill any scotch pines this year.
2. Death by 1000 cankers-Walnut decline is a concern in several cities with bark beetles, Geosmithia and Fusarium canker involvement.
3. Aspen dieback in the mountains is a large issue and we will start a study on this problem this fall to define this issue.

New Insect Issues

1. Bark beetles are killing limber pine and lodgepole pine in dramatic proportions.
2. Leaf mining on elms by flea weevil and elm leaf miner.
3. Pityophthorus julandis on walnuts.

Publications

Costello, S.L. Negron, J.F., Jacobi, W.R. 2007. Evaluating traps and attractants for surveying adult wood borer populations in ponderosa pine of the Black Hills, South Dakota. Journal of Economic Entomology. Accepted.

Jacobi, W.R., Koski, R.D., Harrington, T.C., Witcosky, J.J. 2007. Association of Ophiostoma novo-ulmi with *Scolytus schevyrewi* Semenov (Scolytidae) in Colorado. Plant Disease: 91:245-247.

Keanrs, H.S.J., Jacobi. W.R. 2007. The distribution and incidence of white pine blister rust in central and southeastern Wyoming and northern Colorado. Canadian Journal of Forest Research 37:1-11.

Burns, K.S., Schoettle, A.W., Jacobi, W.R., Mahalovich, M.F. 2008. White Pine Blister Rust in the Rocky Mountain Region and Options for Management. Gen. Tech. Rep. RMRS-GTR-206. Fort Collins, CO: USDA Forest Service, Rocky Mountain Research Station. 26 p.

Goodrich, B.A., Koski, R.D, Jacobi, W.R. 2008. Roadside vegetation health condition and Magnesium Chloride (MgCl2) dust suppressant use in two Colorado counties. Arboriculture and Urban Forestry 34:252-259.

Goodrich, B.A. Jacobi, W.R. 2008. Magnesium Chloride (MgCl2) toxicity in trees. CSU Extension fact sheet No. .425

Jacobi, W.R., Zeglan, S., Beale, J.D. 2008. Black stain root disease progression in coastal Douglas-fir in British Columbia. Canadian Journal of Plant Pathology 30: 339-344.

Kearns, H.S.J., Jacobi, W.R., Burns, K.S., Geils, B.W. 2008. Distribution of Ribes, an alternate host of white pine blister rust, in Colorado and Wyoming. Journal of the Torrey Botanical Society 135: 423-437.

Goodrich, B.A., Koski, R.D, Jacobi, W.R. 2008. Condition of soils and vegetation along roads treated with Magnesium chloride for dust suppression. Water, Air Soil Pollution 198(1-4):165-188.

Kearns, H.S.J., Jacobi, W.R., Geils, B.W. 2008. A method for estimating white pine blister rust canker age on limber pine in the central Rocky Mountains. Forest Pathology 39(3):177-191.

Region 5 Forest Health Protection Pacific Southwest Region

Personnel Changes:

Northern California Shared Service Area

•Hired Cynthia Snyder as new staff entomologist (from Region 10 FHP, Anchorage).

South Sierra Shared Service Area

•Promoted Joel Egan from STEP student at Northeastern California Shared Service Area to Entomologist at South Sierra Shared Service Area.

Northeastern California Shared Service Area

•Promoted Amanda Garcia from STEP student at Northeastern California Shared Service Area to Entomologist at Northeastern California Shared Service Area.

Southern California Shared Service Area

•Hired Paul Zambino as new staff plant pathologist (from Rocky Mountain Research Station).

•Hired Tom Coleman as new staff entomologist (from University of Georgia, Athens).

Remote Sensing Lab

•RSL unit moved from McClellan to new office in Davis, CA.

•Mike Bohne left R5 Forest Health Monitoring Program Coordinator position to become FHP Group Leader of the Northeastern Area- Durham Field office in Durham, NH. There are no immediate plans to refill the R5 FHM position, pending budget changes.

•Walter Clevinger left position as Aerial Survey Program Manager. Zack Heath detailed in the position, which is now in the selection process.
•Eric Haunreiter left position as GIS analyst to take a position with the Nature Conservancy. Megan Woods filled the position.
•Dan Huerta hired as part-time STEP student, working on insect and disease databases.
•Vacant aerial survey specialist position is in the process of being filled.

Ongoing Pathology Projects By Size Category:

Humongous Pathology Projects

1. Sudden Oak Death management and coordination

Big Pathology Projects

1. Regionwide Insect and Disease management training (in 2008, sessions were held in Susanville and San Bernardino. Two more sessions are planned for 2009)
2. White pine blister rust monitoring and management and installation of high elevation foxtail pine monitoring plots.
3. Port-Orford-cedar root disease (including GIS mapping standardization, maintenance of disease eradication projects and plans for planting new burned areas with disease-resistant POC stock).
4. *Heterobasidion annosum.*
5. Black stain root disease.
6. Hazard tree management.
7. Aerial survey, risk mapping and modeling.
8. Mistletoe (both dwarf and leafy).
9. Drought Stress.

Medium Pathology Projects

1. Cytospora.
2. *Puccinia psidii* (guava rust).
3. Ozone damage

Small Pathology Projects

1. *Stigmina thujina* survey at Humboldt nursery
2. Cylindrocarpon destructans survey at Placerville nursery.
3. *Xylella fastidiosa* (sweetgum leaf scorch and maple leaf scorch).
4. Animal damage (porcupines/ bears/ deer/ pocket gophers).

Marcus Jackson

In Memoriam

Lewis F. Roth (April 12, 1914 – September 24, 2008)

Professor Emeritus of Botany and Plant Pathology, died recently in Albany Oregon.

He was born at Poplar, Montana on the Sioux-Assiniboine Indian reservation, the second child of Edith (Herron) and Burton Roth. His dad was an agricultural advisor for the Bureau of Indian Affairs, and Lew attended grade school in Poplar, San Carlos, Arizona, and on the Paiute-Shoshone reservation at Owyhee, Nevada. From childhood he recalled the beauty of the unbroken Montana prairie and the western desert flora and much of his later research career was spent in the dry pine forests of the West.

When Burton Roth left the Indian Service the family moved to Oxford, Ohio where Lewis finished school and attended Miami University. He graduated with a BA degree in Botany and then attended the University of Wisconsin where he earned his Ph.D. After a brief period at the U.S.D.A. Forest Products Laboratory in Madison he moved, in 1940, to Oregon State University as a mycologist and plant pathologist. He continued there, teaching and advising graduate students until retirement in 1979, and remained active in an emeritus role until very recently.

In 1942 he enlisted in the navy hospital corps and served in the Great Lakes and Portsmouth hospitals and at a medical supply depot in Norfolk, Virginia. He was later commissioned ensign in the supply corps. Following supply training at Harvard Business School he spent 3 years as division officer and paymaster on the escort aircraft carrier CARD, engaged in Atlantic antisubmarine warfare through D-day, and then in the Pacific through the end of the war. Upon return from sea he served as supply officer at the Naval Air Station at Klamath Falls, Oregon. After release from active duty he continued with the Office of Naval Research and retired after 22 years with the rank of commander.

November 5, 1945, in Corvallis, he married Evelyn (Lyn) Swaim, then with the Oregon Department of Education. They had two daughters. Evelyn became a close colleague in much of Lew's work. The family spent many summers at field sites in the West. Lew was particularly fond of the memory of Lyn's contributions to his mistletoe research at the Pringle Falls Experimental Forest. They were trying to trap the sticky mistletoe seeds as they were forcibly discharged from the plants, but the seeds just bounced off of the targets Lyn was holding up as traps. The seeds were caught very efficiently in Lyn's hair, however. Not only did the marriage survive the subsequent painful combing, but Lew realized that the resilient needles of trees were the natural landing place for mistletoe seeds, not rigid branches and boles.

In research as in teaching he was dedicated to service, a philosophy he instilled in his students. This brought him close to the forestry community, which funded much of his research and promptly applied results. New knowledge of seven major diseases became effective parts of forest practice. He continued after retirement to do private consulting at home and abroad. This took the couple to Europe, Australia, Taiwan, Argentina and New Zealand. One of his great pleasures in retirement was continued professional work with a number of his former students.

His contributions to forest pathology were based on observation and understanding of fungal ecology and forest management, as well as experimentation. Successful management of disease in the forest relied first and foremost on forest managers and forest engineers, using the tools of silviculture and forest harvest. Lew's goal in 39 years of teaching was to instill forestry students and professionals with the necessary knowledge of pathogen biology and ecology to allow them to establish and maintain healthy, productive forests. He and his students made many contributions to the science of plant pathology in support of this goal.

His PhD thesis research, with A.J. Riker, explored the interactions between soil environment, *Pythium* and *Rhizoctonia*, and pine seedlings, and led to one of the early demonstrations of effective biological control of damping off disease. He and his graduate students demonstrated the systemic colonization of ponderosa pine by *Elytroderma*, thus explaining the recurrent nature of pine needle cast epidemics. They clarified the infection biology and measured the impacts of several tree decay fungi. Lew and his students elucidated the growth and behavior of two invasive *Phytophthora* species, and with Forest Service silviculturalists and

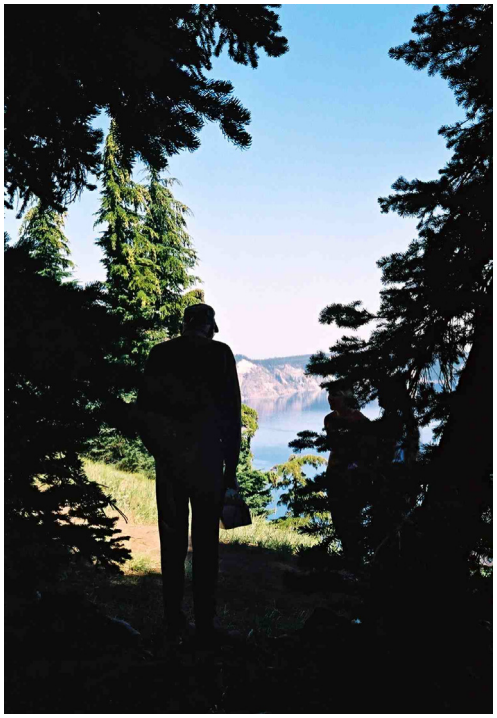
university ecologists established the basis for successful management of cedar root rot, including disease resistance. Lew worked with company foresters and graduate students to understand Armillaria root rot in ponderosa pine, and then applied the information in large scale demonstrations of management techniques. Similarly, with his students and Forest Service research silviculturalists, he worked out the dynamics of dwarf mistletoe seed dispersal and infection of ponderosa pine. This led to one of the first epidemiological models in forest pathology, and to practical recommendations for growing pine in the presence of mistletoe.

Lew thought big, and didn't shy from the big experiments needed to test his ideas. One of his mistletoe seed dynamics installations was spotted by a passing airline pilot, and called in to the FAA as a crashed airplane. His "potato patch" experiment and associated demonstrations and applications of stump removal for *Armillaria* control cover hundreds of acres of pine forest. His research was primarily field-based and he and his students pulled a small travel trailer to field sites. The close quarters and other challenges of trailering provided grist for many stories.

Lew was elected Fellow of the American Phytopathological Society in 1980, and in 2000, was co-recipient of the first Outstanding Achievement Award from the Western International Forest Disease Work Conference (WIFDWC). He was cited for "Pioneering work on *Phytophthora lateralis*, *Armillaria*, and dwarf mistletoe, and for inspiration and leadership of a generation of plant pathology students and colleagues." In 2005, Forest Service colleagues dedicated the "Lewis Roth Dwarf Mistletoe Trail" on the Deschutes National Forest to commemorate and continue Lew's contributions to public understanding and appreciation of mistletoe.

Lew and Lyn gave generously to the University and to cultural activities in the state. They donated their tree farm to the Department of Botany and Plant Pathology for teaching and research in a managed forest context, made gifts to the OSU Library and established an endowment to support graduate education, and were benefactors of the Oregon Shakespeare Festival.

Lew was preceded in death by his loving wife, Evelyn on March 20, 1999. He is survived by his daughters Kathy of Corvallis, Sara of Oregon City, granddaughter Jenna Miller of Portland, and special friend Karen Burr of Albany. Remembrances may be made to the Lewis F. and Evelyn S. Roth Scholarship and Education Fund through the OSU Foundation, 850 SW 35th St., Corvallis OR 97333.



Lew Roth at Crater Lake
Photo by Pete Angwin

In Memoriam

Ed F. Wicker (August 21, 1930 – March, 20 2008)

Ed Franklin (Frank) Wicker, 77, passed away Thursday, March 20, 2008, at his home after a two-year battle with cancer.

He was born Aug. 21, 1930, in Upper Tygart, Ky., the third of 13 children of Leslie and Bessie Hamilton Wicker. He attended elementary school in Wheelersburg, Ohio, and graduated from high school in Portsmouth, Ohio. When not in school, he helped on the family farm. He enjoyed telling stories of those days - plowing with mules, hunting with hounds and working hard to get a large family through the Depression and war years.

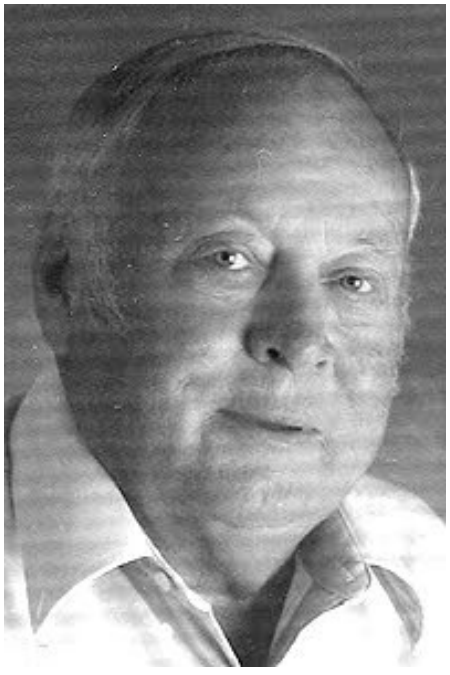
In 1950 he joined the Air Force for four years and served during the Korean War. While stationed at McChord Air Force Base in Tacoma, he met Veneta Law in 1952. They were married in Port Angeles, Wash., on Dec. 20, 1953. He attended Washington State University in Pullman 1955-1963, earning a bachelor's degree in forestry and a Ph.D. in plant pathology.

He worked as a research scientist for the U.S. Forest Service from 1955-1992. His career took him to Moscow, Washington, D.C., and Fort Collins, Colo., where he retired as assistant director of research for the 14-state Rocky Mountain Region. He took his family along on two research sabbaticals to Europe and Japan in the 1970s.

He was a member in Moscow of the Elks, Eagles and Lions clubs.

After retirement, he returned with his wife to Moscow, where he enjoyed gardening, golfing, fishing, hunting and traveling south in winter and spring.

He is survived by his wife of 54 years, Veneta at their Moscow home; daughters and their families, Joel and Cynthia King and son Philip of Moscow, and Colin and Sonja Takatori and sons Jason and Lucas of Mukilteo, Wash.; brothers, Duke and Carl; sisters, Norma Nolan, Reba Ann Willis, LaVern Allen, Jinny Dundon and Alma Willis; sister-in-law, Winona Hutchison; and numerous nieces and nephews.



In Memoriam

Albert R. Stage

Albert R. Stage, 79, Emeritus Scientist, died on Saturday, July 12, 2008 at home near Moscow, ID.

Al was one of the giants in forest biometrics research and forest growth dynamics modeling in the world. His broad breadth of knowledge, analytical skills, creativity and curiosity, and his sheer love of science, made him a consummate forest scientist. It is noteworthy that his most productive year measured in refereed journal papers was 2007, many years after becoming an Emeritus Scientist. He had more work to do and many more papers planned than his lifetime permitted. Al was best known for the creation of the Prognosis Model for Stand Development, first published in 1973. This model is the core of what is currently known as the Forest Vegetation Simulator (FVS), the most widely used forest growth model in the world. Al's vision, his quiet but persuasive prodding, and his firm grasp of biophysical, mathematical, and statistical concepts are at the foundation of FVS. Many who had the pleasure of working closely with him stand in awe of his achievements; the fervor and pace with which Al attacked forestry research was exhausting! Al's Forest Service career started in 1950 with a summer job at the Fort Valley Experimental Forest in Arizona. In 1951 he was hired by the Northern Rocky Mountain Forest and Range Experiment Station and when not on military or educational leave, he supervised the Priest River Experimental Forest in northern Idaho until 1956. He received an M.S. in Mathematical Statistics (1961) and a Ph.D. in Forest Mensuration (1966), both from the University of Michigan. Al was one of the original inhabitants of the Moscow Forestry Sciences Laboratory when it opened in 1963. It was there that he was appointed to his dream job as a project leader, a position he maintained until retirement in 1995. Al received several awards and honors during his career, including the Distinguished Alumni Award from the University of Michigan's School of Natural Resources, the USDA Superior Service Award, the Forest Service Forest Insect and Disease Award for Research Excellence, and in 2006, the Society of American Foresters (SAF) Award in Forest Science. He was elected a Fellow of SAF in 2000.

Standing Committees and Chairs, 1994—2008

Committee	Chairperson	Term
Hazard Trees	J. Pronos	1994-2005
	P. Angwin	2006—2008
Dwarf Mistletoe	R. Mathiasen	1994—2000
	K. Marshall	2001—2003
	F. Baker	2004—2007
	G. Filip	2008
Root Disease	G. Filip	1994—1995
	E. Michaels Goheen	1996—2005
	B. Ferguson	2006—2008
Rust	J. Schwandt	1994, 2005
	R. Hunt	1995-2004
	H. Kearns	2006—2008
Disease Control*	B. James	1995-2002
Nursery Pathology	B. James	2002-2005
	K. Mallams	2007-2008
Ad Hoc Committes 2008		
Climate Change	T. Shaw	2007
Foliar and Shoot Diseases	H. Kope	2007-2008
Foliage/Twig Disease Committee	H. Kope	2007-2008

*Disease Control was disbanded and Nursery Pathology established in 2002.

Past Annual Meeting Locations and Officers

Meetings and Officers, 1953—1989

Annual	Year	Location	Chairperson	Secretary-Treasurer	Program Chair	Local Arrangements
1	1953	Victoria, BC	R. Foster			
2	1954	Berkeley, CA	W. Wagener	P. Lightle		
3	1955	Spokane, WA	V. Nordin	C. Leaphart	G. Thomas	
4	1956	El Paso, TX	L. Gill	R. Davidson	V. Nordin	
5	1957	Salem, OR	G. Thomas	T. Childs	R. Gilbertson	
6	1958	Vancouver, BC	J. Kimmey	H. Offord	A. Parker	
7	1959	Pullman, WA	H. Offord	R. Foster	C. Shaw	
8	1960	Centralia, WA	A. Parker	F. Hawksworth	J. Parmeter	K. Shea
9	1961	Banff, AB	F. Hawksworth	J. Parmeter	A. Molnar	G. Thomas
10	1962	Victoria, BC	J. Parmeter	C. Shaw	K. Shea	R. McMinn
11	1963	Jackson, WY	C. Shaw	J. Bier	R. Scharpf	L. Farmer
12	1964	Berkeley, CA	K. Shea	R. Scharpf	C. Leaphart	H. Offord
13	1965	Kelowna, BC	J. Bier	H. Whitney	R. Bega	A. Molnar
14	1966	Bend, OR	C. Leaphart	D. Graham	G. Pentland	D. Graham
15	1967	Santa Fe, NM	A. Molnar	E. Wicker	L. Weir	P. Lightle
16	1968	Couer D'Alene, ID	S. Andrews	R. McMinn	J. Stewart	C. Leaphart
17	1969	Olympia, WA	G. Wallis	R. Gilbertson	F. Hawksworth	K. Russell
18	1970	Harrison Hot Springs, BC	R. Scharpf	H. Toko	A. Harvey	J. Roff
19	1971	Medford, OR	J. Baranyay	D. Graham	R. Smith	H. Bynum
20	1972	Victoria, BC	P. Lightle	A. McCain	L. Weir	D. Morrison
21	1973	Estes Park, CO	E. Wicker	R. Loomis	R. Gilbertson	J. Laut
22	1974	Monterey, CA	R. Bega	D. Hocking	J. Parmeter	
23	1975	Missoula, MT	H. Whitney	J. Byler	E. Wicker	O. Dooling
24	1976	Coos Bay, OR	L. Roth	K. Russell	L. Weir	J. Hadfield
25	1977	Victoria, BC	D. Graham	J. Laut	E. Nelson	W. Bloomberg
26	1978	Tucson, AZ	R. Smith	D. Drummond	L. Weir	R.Gilbertson
27	1979	Salem, OR	T. Laurent	T. Hinds	B. van der Kamp	L. Weir
28	1980	Pingree Park, CO	R. Gilbertson	O. Dooling	J. Laut	M. Schomaker
29	1981	Vernon, BC	L. Weir	C.G. Shaw III	J. Schwandt	D. Morrison R. Hunt
30	1982	Fallen Leaf Lake, CA	W. Bloomberg	W. Jacobi	E. Hansen	F. Cobb J. Parmeter
31	1983	Coeur d'Alene, ID	J. Laut	S. Dubreuil	D. Johnson	J. Schwandt J. Byler
32	1984	Taos, NM	T. Hinds	R. Hunt	J. Byler	J. Beatty E. Wood
33	1985	Olympia, WA	F. Cobb	W. Thies	R. Edmonds	K. Russell
34	1986	Juneau, AK	K. Russell	S. Cooley	J. Laut	C.G. Shaw III
35	1987	Nanaimo, BC	J. Muir	G. DeNitto	J. Beatty	J. Kumi
36	1988	Park City, UT	J. Byler	B. van der Kamp	J. Pronos	F. Baker
37	1989	Bend, OR	D. Goheen	R. James	E. Hansen	A. Kanaskie

Meetings and Officers, 1990—2008

Annual	Year	Location	Chair-person	Secretary	Treasurer	Program Chair	Local Arrangements	Historian	Web Coordinator
38	1990	Redding, CA	R. Hunt	J. Hoffman	K. Russell	M. Marosy	G. DeNitto		
39	1991	Vernon, BC	A. McCain	J. Muir	K. Russell	R. Hunt	H. Merler		
40	1992	Durango, CO	D. Morrison	S. Frankel	K. Russell	C.G. Shaw III	P. Angwin		
41	1993	Boise, ID	W. Littke	J. Allison	K. Russell	F. Baker	J. Hoffman		
42	1994	Albuquerque,NM	C.G. Shaw III	G. Filip	K. Russell	M. Schultz	D. Conklin T. Rodgers		
43	1995	Whitefish, MT	S. Frankel	R. Mathiasen	K. Russell	R. Mathiasen	J. Taylor J. Schwandt		
44	1996	Hood River, OR	J. Kliejunas	J. Beatty	J. Schwandt	S. Campbell	J. Beatty K. Russel		
45	1997	Prince George, BC	W. Thies	R. Sturrock	J. Schwandt	K. Lewis	R. Reich K. Lewis		
46	1998	Reno, NV	B. Edmonds	L. Trummer	J. Schwandt	G. Filip	J. Hoffman J. Guyon	D. Morrison	
47	1999	BreckenridgeCO	F. Baker	E. Michaels Goheen	J. Schwandt	J. Taylor	D. Johnson		J. Adams
48	2000	Waikoloa, HI	W. Jacobi	P. Angwin	J. Schwandt	S. Hagle	J. Beatty		
49	2001	Carmel, CA	D. Johnson	K. Marshall	J. Schwandt	A. Kanaskie	S. Frankel		
50	2002	Powell River, BC	B. van der Kamp	H. Maffei	J. Schwandt	P. Hennon	S. Zeglen R. Diprose		
51	2003	Grants Pass, OR	E. Hansen	B. Geils	J. Schwandt	H. Merler	E. Michaels Goheen		
52	2004	San Diego, CA	E. Goheen	B. Lockman	J. Schwandt	H. Merler K. Lesiw	J. Pronos J. Kliejunas S. Smith		
53	2005	Jackson, WY	M. Fairweather	H. Merler J. Guyon	J. Schwandt	K. Burns	J. Hoffman F. Baker J. Guyon		
54	2006	Smithers, BC	K. Lewis	M. Jackson	J. Schwandt	B. Lockman	A. Woods		
55	2007	Sedona, AZ	S. Zeglen	M. McWilliams	J. Schwandt	J. Worrall	M. Fairweather B. Geils B. Mathiason		
56	2008	Missoula, MT	G. DeNitto	F. Baker	J. Schwandt	W. Littke	B. Lockman M. Jackson		

Bylaws passed in 1998 WIFDWC Business Meeting identify officers as chairperson and secretary elected at annual business meeting and treasurer and historian, elected every five years.

2008 WIFDWC ATTENDEES

We are currently updating our membership list. A complete list will appear in the 2009 proceedings

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