Proceedings of the 57th Annual Western International Forest Disease Work Conference

July 20-24, 2009
Durango, Colorado

Compiled by: Judy Adams
Forest Health Technology Enterprise Team
Fort Collins, CO

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Forest Health Technology Enterprise Team
Fort Collins, CO
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PROGRAM

Monday, July 20th

1:00 - 3:00 pm	Nursery Pathology Committee Meeting (Katy Mallams, Committee Chair)
3:00 - 7:00 pm	Rust Committee Meeting (Holly Kearns, Committee Chair)
4:00 - 8:00 pm	Registration
7:00 – 10:00 pm	Welcome Social

Tuesday, July 21st

7:00 - 8:30 am	Foliage/Shoot Disease Committee Breakfast Meeting (Bill Jacobi, Chair)
8:00 – 5:00 pm	All Day Registration
8:30 - 8:45 am	Welcome from WIFDWC Chair Greg Filip
8:45 - 9:00 am	Keynote Speaker: Ros Wu, San Juan National Forest
9:45 – 10:00 am	2009 Outstanding Achievement Award – Bill Jacobi
10:00 - 10:30 am	Break
10:30 - 12:00 am	Student Session (Moderated by Besty Goodrich)
12:00 - 1:30 pm	Climate Change Committee Lunch **(**Susan Frankel, Committee Co-chair)
1:30 - 3:15 pm	**Panel: Aspen Health (Moderated by Jim Worrall)**

1 Diseases and Insects Associated with Sudden Aspen Decline in Southwestern Colorado. Suzanne Bethers, Jim Worrall & Tom Eager
2 Cytospora Canker Complex on Colorado's Aspen. Jeff Kepley, Brent Reeves & Gerry Adams
3 Aspen Condition in Northern Wyoming and Western South Dakota. James T. Blodgett & Kurt K. Allen
4 Monitoring the Condition of Aspen in the Northern and Intermountain Regions. John C. Guyon II, James T. Hoffman, Holly Kearns & Brytten Steed

3:15 – 3:30 pm	Break
3:30 – 5:00 pm	**Panel: White Pine Blister Rust (Moderated by Holly Kearns)**

1 White Pine Blister Rust in the Interior Mountain West." Kelly Burns, Jim Blodgett, Dave Conklin, Brian Geils, Jim Hoffman, Marcus Jackson, William Jacobi, Holly Kearns & Anna Schoettle
2 White Pine Blister Rust on New Telial Hosts (*Castilleja* and *Pedicularis*) in Whitebark Pine Ecosystems at Mt. Rainier and Crater Lake National Parks." Robin Mulvey

7:00 – 9:00 pm	**Poster Session (Moderated by Meg Dudley)**

1 Swiss Needle Cast of Douglas-Fir in Oregon and the Swiss Needle Cast Cooperative. David Shaw, Travis Woolley, Alan Kanaskie, Douglas Maguire & Greg Filip
2 Limber Pine Health Survey in the Rocky Mountains and North Dakota. James T. Blodgett, Kelly S. Burns, Brian Howell, Marcus Jackson, William R. Jacobi & Anna Schoettle
3 The Forest Insect and Pathogen Hazard Rating System Database. Andrew J. McMahan & Eric L. Smith
4 The Geographic Distribution of Red Fir and Noble Fir Based on Infection by Pacific Silver Fir Dwarf Mistletoe." Carolyn M. Daugherty & Robert L. Mathiasen
5 Characterization of Partial Resistant Western White Pine Trees Against White Pine Blister Rust Using In-vitro Screening Techniques. D. Noshad,

J.N. King, R. Sturrock & A.K.M. Ekramoddoullah

6 Induced Fruiting of *Phellinus sulphurascens*. Kevin W. Pellow & Rona N. Sturrock

Wednesday, July 22nd

7:30 – 10:30 pm	Field Trip and Barbeque

Thursday, July 23rd

7:00 - 8:30 am	Hazard Tree Committee Breakfast Meeting (Mary Lou Fairweather, Chair)
8:30 - 9:45 am	Business Meeting
9:45 – 10:00 am	Break
10:00 – 12:00 am	**Panel: High Elevation Forest Declines (Moderated by Kristen Chadwick)** 1 Subalpine Fir Decline in Southern Idaho. Laura Lazarus 2 Balsam Woolly Adelgid – an Emerging Architect of High Elevation Forest in the West. Kris Chadwick, Lia Spiegel & Connie Mehmel 3 Whitebark Pine Restoration Program – History and Progress. John Schwandt & Holly Kearns
12:00 – 1:30 pm	Root Disease Committee Lunch Meeting (Mike Cruikshank, Acting Chair)
1:30 – 3:15 pm	**Panel: New Pathogens: Are We Up the Creek Without Our Paddle? (Moderated by Will Littke)** 1 Determining if There are Lines of Guava Rust (*Puccinia psidii*) That Could Seriously Impact Ohia (*Metrosideros polymorpha*), in Hawaii. Philip G. Cannon, Acelino Couto Alfenas, Rodrigo Garca Neves, Mee-Sook Kim, Tobin Peever & Ned Klopfenstein 2 *Phytophthora pinifolia* on *Pinus radiata* in Chile. Phil Cannon 3 Pests- Pacific Rim & Beyond-Identifying New Potential Pathogens. Will Littke 4 A National View…Early Detection Rapid Response (EDRR), FHM Evaluation Monitoring, and EXFOR and Risk Analysis." Bruce Moltzan
3:15 – 3:30 pm	Break
3:30 – 5:00 pm	**Panel: Back to the Future: New and Historical Perspectives on Wood Decays (Moderated by Jessie Micales-Glaeser)** 1 Decay of Fire-Killed Western Larch." Marcus Jackson

Friday, July 24th

7:00-8:30 am	Dwarf Mistletoe Committee Breakfast Meeting (Fred Baker, Committee Chair)
8:30 – 12:00 pm	**Special Papers (Moderated by Bill Jacobi)** 1 Site, Plot, and Individual Stem Volume Variation of Douglas-fir Associated with Non-lethal Infections by Armillaria Root Disease in Southern British Columbia. Mike Cruickshank 2 Overview of Douglas-fir—*Phellinus sulphurascens* Pathosystem Research. Rona Sturrock 3 Proposed Nomenclatural Changes in *Arceuthobium*: Published and Forthcoming." Bob Mathiason 4 Susceptibility and Sporulation Potential of *Phytophthora ramorum* on Some Common Plants in Washington Forests." Marianne Elliott & Gary Shastagner
12:00 pm	Adjourn

2009 WIFDWC Outstanding Achievement Award

William (Bill) Jacobi, Professor of Plant Pathology at Colorado State University, is the recipient of the 2009 Western International Forest Disease Work Conference Outstanding Achievement Award. Bill has for many decades supported and spoken for western forest pathology. Bill is recognized for his decades of work in the field of forest pathology and his numerous achievements in research, extension, teaching, and advising. His accomplishments can be attributed to three important character virtues that Bill well exhibits—careful scientific methodology, concern for students and coworkers, and commitment to the work.

Since 1980, Bill has been a faculty member at Colorado State University in the Department of Bioagricultural Sciences and Pest Management with joint appointments in Forestry and Ecology. In his thirty years as a professor, Bill has advised many students in MS or PhD programs and taught hundreds of undergraduate students about forest health. In 2002, Colorado State University awarded Bill the Jack E. Cermak Advising Award, which serves to highlight "the extraordinary efforts of truly outstanding advisers who go above and beyond the basic good advising role." His commitment to students, their education, and their career development is unparalleled.

Bill is dedicated and knowledgeable, and his work has advanced our knowledge and thinking on many subjects. He has contributed an extensive body of research on an amazing variety of forest pathogens including comandra and white pine blister rusts, black stain and Armillaria root diseases, dwarf mistletoes, and Cytospora and Thyronectria canker diseases that have been critical to our understanding of these pathosystems. The research undertaken by students in the Forest and Shade Tree Health Lab is just as wide-ranging and includes abiotic diseases; exotic insect and disease pathways; ecological consequences and spatial distribution of diseases; technology transfer; environmental influences on disease occurrence; and insect, pathogen and fire fuel interactions.

In addition to all the contributions Bill has made to the education and development of forest health professionals, he is known for his passion for the field and the inspiration and motivation of those around him. He leaves positive relationships everywhere he goes, which certainly says a lot about the legacy that Bill continues to build in the field of forest health. Bill continues to have a tremendous impact on the field of forest pathology – through his own work, collaborative efforts, and the work of his many students.

Bill Jacobi - Outstanding Achievement
Award Recipient
2009 WIFDWC

WIFDWC 2009 Outstanding Achievement Award Nomination Letter for Robert L. Edmonds

From: David Shaw, Will Littke and others

Robert Edmonds, Professor of Forest Pathology and Soil Microbiology, and Associate Dean for Research, University of Washington, College of Forest Resources, is a long time member of WIFDWC (1968) who has, over the past 40 years, contributed an immense body of work (113 publications), as well as students, to the field of forest pathology. Perhaps one of the best examples of this is the book, ***Forest Health and Protection***, which he co-wrote with Bob Gara (entomology) and Jim Agee (fire). This book is currently being updated, and will come out again soon, but it is a significant synthetic book that holistically covers the central subjects of forest health and protection.

Dr. R. Edmonds' forest pathology focus has been on root diseases, wood decays, and soil microbiology (decomposition and mycorrhizae). His first publication in 1969 was with Charlie Driver and Ken Russell, in the Plant Disease Reporter, titled: ***Borax and control of stump infection by Fomes annosus in western hemlock.*** He helped determine that precommercial thinning in western hemlock was not a major threat to managed stands, and he has led the way in helping silviculturists understand how to manage western hemlock in coastal forests of North America. Bob also studied spores dispersal of Annosus, and went on to head an Aerobiology Institute in Michigan, before returning to University of Washington.

Perhaps one of the most significant aspects of Bob's approach is that he has integrated forest pathology into ecosystem science, and included it in the broader picture. Although less significant to pathologists directly, this has been extremely important in illuminating the role of forest pathogens to non-forest pathologists, and has helped the other sciences understand the importance of forest pathology.

Robert L. Edmonds

Nominee's qualifications

EDUCATION

B.S.	1964	Sydney University, Sydney, Australia Dip. For. Australian Forestry School, Canberra, Australia
M.S.	1968	University of Washington, Seattle, Washington (Thesis title) - Natural Occurrence and Control of *Fomes annosus* in Precommercially Thinned Stands of Western Hemlock
Ph.D.	1971	University of Washington, Seattle, Washington (Dissertation title) - Diffusion and Deposition of *Fomes annosus* Spores and Fluorescent Particles into and within a Forest Canopy

PROFESSIONAL EXPERIENCE

1964-1965	Research Forestry Officer, Tree Breeding and Improvement Section and Seed Section, Forest Research Institute, Canberra, Australia
1965-1966	Research Assistant, Pine nursery disease problems, Department of Forestry, Australian National University, Canberra, Australia

1966-1970	Research Assistant, College of Forest Resources, University of Washington, Seattle, Washington
1971	Research Associate, US/IBP coniferous Forest Biome, University of Washington (January through June)
1971-1973	Program Coordinator to Director, US/IBP Aerobiology Program, Botany Department, University of Michigan, Ann Arbor, Michigan
1973-1976	Associate Director, US/IBP Coniferous Forest Biome, Director US/IBP Aerobiology Program, and Research Assistant Professor, College of Forest Resources, University of Washington, Seattle, Washington
1976-1979	Assistant Professor, Director of Pack Forest and Associate Director, Coniferous Forest Biome
1979-1982	Associate Professor
1982-	Professor
1984-1986	Vice Chairman, Forest Resources Management, College of Forest Resources
1993-1997	Chair, Ecosystem Science and Conservation Division, College of Forest Resources
2000-2001	Chair, Ecosystem Sciences Division, College of Forest Resources
2001-	Associate Dean for Research, College of Forest Resources

Professor R.L. Edmonds has 113 publications!

Selected pubs:

Browning, J.E. & R.L. Edmonds. 1993. Influence of soil aluminum and pH on Armillaria root rot in Douglas-fir in Western Washington. Northwest Science 67(1) pp. 37-43.

Farr, D., F.M. Elliott, A.Y. Rossman, & R.L. Edmonds. 2005. *Fusicoccum arbuti sp. nov*. causing cankers on Pacific madrone in western North America with notes on *Fusicoccum dimidiatum*, the correct name for *Scytalidium dimidiatum* and Nattrassia. Mycologia 97(3) pp. 730-741.

Elliott, M. & R.L. Edmonds. 2008. Injected treatments for management of madrone canker. Arboriculture and Urban Forestry 34(2) pp. 110-115.

Edmonds, R.L., J.K. Agee & R.I. Gara. 2005. Forest Health and Protection. Waveland Press, Long Grove, IL.

Edmonds, R.L. 1996. Inoculum, p. 164-184 in F.H. Tainter and F.A. Baker (eds.). Principles of Forest Pathology, John Wiley and Sons, Inc. New York, NY.

Littke, W.R., C.S. Bledsoe, N.M. Nadkarni, & R.L. Edmonds. 1980. Technique for rapid mycorrhizal colonization of container-grown Douglas-fir by *Hebeloma crustuliniforme*. Soil Biology and Biochemistry 12(6) pp. 575-578.

Littke, W.R., C.S. Bledsoe & R.L. Edmonds. 1984. Nitrogen uptake and growth in vitro by *Hebeloma crustuliniforme* and other Pacific Northwest mycorrhizal fungi. Can. J. Bot. 62 pp. 647-652.

Shaw, D.C., R.L. Edmonds, W.R. Littke, J.E. Browning, & K.W. Russell. 1995. Incidence of wetwood and decay in precommercially thinned western hemlock stands. Can. J. For. Res. 25 pp. 1269-1277.

Hsiang, T., R.L. Edmonds & C.H. Driver. 1989. Conidia of *Heterobasidion annosum* from *Tsuga heterophylla* forests in western Washington. Can. J. Bot. 67 pp. 1262-1266.

Edmonds, R.L., K.B. Leslie & C.H. Driver. 1984. Spore deposition of *Heterobasidion annosum* in thinned coastal western hemlock stands in Oregon and Washington. Plant Dis. 68 pp. 713-715.

Edmonds, R.L. (ed.). 1982. Analysis of Coniferous forest ecosystems in the western United States. US/IBP Synthesis Series. Hutchinson Ross, Stroudsburg, Pennsylvania. 419 p.

Edmonds, R.L. & W.A. Heather. 1973. Root diseases in pine nurseries in the Australian Capital Territory. Plant Disease Reporter 57 pp. 1058-1062.

Edmonds, R.L., C.H. Driver & K.W. Russell. 1969. Borax and control of stump infection by *Fomes annosus* in western hemlock. Plant Disease Reporter 53 pp. 216-219.

List of WIFDWC members that were students of R. Edmonds (published or worked very closely with him).

Susan Frankel, John Browning, Will Littke, Dave Shaw, Amy Ramsey, Craig Schmidt, Marianne Elliott, and Anna Leon (current MS graduate student).

KEYNOTE ADDRESS

Forest change in the San Juan Mountains

Rosalind Wu
USDA Forest Service, San Juan National Forest, Pagosa Ranger District, Colorado 81147 USA

Abstract

Forests change through time and their development is shaped by climate and disturbance histories. Written historical records of a forest provide only brief views of past events that are inadequate for understanding long term forest dynamics. Dendrochronological (tree-ring) methods give researchers and managers a tool with which to look back at multi-century time scales of forest development and disturbance to gain a better understanding of their dynamics and forcing mechanisms. The data and results presented in this talk were published in the paper Climate and Disturbance Forcing of Episodic Tree Recruitment in a Southwestern Ponderosa Pine Landscape (Brown and Wu 2005). Other tree-ring studies have shown ponderosa forests were open park-like stand maintained by frequent surface fires (Cooper 1960, Fulé et al 1997). The main findings of Brown and Wu were that climate, wet and dry periods influenced by the El Ninõ-Southern Oscillation (ENSO), exerted a top down regional control on tree recruitment and fire occurrence. Climatic pluvial periods resulted in pulses of tree recruitment seen over much of the Southwest. Such wet periods also corresponded with decreased fire activity that resulted in increased seedling survival. Therefore, fires, mediated by stochastic climate variation, acted as a density independent regulation on tree populations since establishment was not limited by overstory tree density, but rather by fire-caused mortality of seedlings and saplings during periods of more frequent fires. Even-aged cohorts in ponderosa pine forests likely have little to do with episodic mortality caused by more severe fires, but rather relate mainly to episodic recruitment opportunities. Fire cessation after Euro-American settlement in the late 1800s resulted in an increase in tree density and changes in forest composition, which are major factors that have contributed to recent severe wildfires in other Southwestern forests. Bluestain in wood samples show that bark beetles were also active in these ponderosa pine forests. Tree-ring data can provide death dates, but cannot provide an unequivocal cause of death. Recent large and lethal insect outbreaks demonstrate that insects are capable of causing widespread tree mortality at spatial scales that equal or exceed large fires of the past decade. Forest structure and climate are also important factors for insect activity. More research in fire, insect, and climate are warranted to further our understanding of the interactions between them and how they shape our forests through time.

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Brown, P.M. and R.Y. Wu. 2005. Climate and disturbance forcing of episodic tree recruitment in a southwestern ponderosa pine landscape. Ecology 86(11): 3030–3038.

Cooper, C.F. 1960. Changes in vegetation, structure, and growth of southwestern pine forests since white settlement. Ecological Monographs, 30(2) :129-164.

Fulé, P.Z., W.W. Covington, and M.M. Moore. 1997. Determining reference conditions for ecosystem management of southwestern ponderosa pine forests. Ecological Applications 7(3):895-908.

Student Papers
Moderator: Besty Goodrich

"Restoration Planting Options for Limber Pines Impacted by Mountain Pine Beetles and/or White Pine Blister Rust in the Southern Rocky Mountains."
Anne Marie Casper, William R. Jacobi, Anna W. Schoettle & Kelly S. Burns

"Aspen Mortality in the Colorado: Extent, Severity, and Causal Factors."
Megan M. Dudley, William R. Jacobi & Kelly S. Burns

"Spatial and Ecological Analysis of Red Fir Decline in California Using FIA Data."
Leif A. Mortenson

Restoration Planting Options for Limber Pines Impacted by Mountain Pine Beetles and/or White Pine Blister Rust in the Southern Roc Mountains

Anne Marie Casper[1], William R. Jacobi[2], Anna W. Schoettle[3] and Kelly S. Burns[4]

Limber Pine (*Pinus flexilis*) populations in the southern Rock Mountains are severely threatened by the combined impacts of mountain pine beetles and white pine blister rust. Limber pine's critical role these high elevation ecosystems heightens the importance of mitigating impacts. To develop forest-scale planting methods six seedling planting trial sites were installed extending from the Medicine Bow Nation Forest in southern Wyoming to the Great Sand Dunes National Park and Preserve in southern Colorado. At each site six plots were split between high and low density canopy conditions. In these blocks treatments included presence/absence of a nurse object and presence/absence of Terra-Sorb Hydrogel, with six replicates of each treatment combination, for a total of 432 seedling planted in each of the four sites with the Terra-Sorb Hydrogel treatment and216 seedlings planted in both of the two sites without hydrogel treatments. We created nurse objects by burying 50 cm tall tree stem segments (20-40 cm dia) 10 cm in the ground. Trees were planted as close as possible to the object at the four cardinal directions to further test exposure stress. In the check treatment we planted seedlings in an east/west orientation 40cm apart. Terra-Sorb Hydgrogel (Pittsburgh, PA) is a potassium-based co-polymer gel that absorbs up to 200 times its weight in water. Hydrogels are commonly used in horticulture; however scientific literature shows mixed results for tree survival. In hydrogel treatments we dipped seedling roots in a hydrogel slurry before planting, per manufacturer directions, and in check treatments we dipped seedling roots in water before planting. In surrounding natural stands of limber pine we installed transects to sample forest stand structure and determine density and periodicity of regeneration. We will continue monitoring health and survival of the outplanted seedlings, as well as the incidence of natural regeneration in 2010. Results from this project will be used to develop limber pine planting protocols for the southern Rocky Mountains.

Anne Casper

In: Adams, J. comp. 2010. Proceedings of the 57th Western International Forest Disease Work Conference; 2009 July 20-24; Durango, CO. Forest Health Technology Enterprise Team Fort Collins, CO.

[1]Anne Marie Casper, Dept. of Bioagricultural Sciences and Pest Management, Colorado State University
[2]William R. Jacobi, Dept. of Bioagricultural Sciences and Pest Management, Colorado State University
[3]Anna W. Schoettle, USDA Forest Service, Rocky Mountain Research Station, Fort Collins, CO
[4]Kelly S. Burns, USDA Forest Service, Rocky Mountain Region, Forest Health Management, Lakewood Service Center, Golden, CO

Aspen Mortality in the Colorado: Extent, Severity, and Causal Factors

Megan M. Dudley[1], William R. Jacobi[2], and Kelly S. Burns[3]

Populus tremuloides is a deciduous hardwood tree widely distributed throughout North America. Recent observations of widespread dieback have prompted surveys of aspen stands across the western United States and Canada (Worrall et al, 2008, Hogg et al, 2002 and 2008). Our study is part of a larger; Region 2-wide survey of the health of aspen stands occurring on National Forest lands. During the 2009 field season, we surveyed of the aspen forest type on the Pike, San Isabel, White River, and Routt National Forests in Colorado. We have established 144 circular, fixed-area plots (half of them in aspen forests designated as 'damaged' by the 2008 Aerial Detection Survey), along with 195 extensive rapid assessment plots, to determine the overall status of aspen health within each district. During the 2010 field season, we will continue to survey of the aspen forest type within the four national forests

Data collected from adult trees within each fixed area plot include: tree species present; the number of trees DBH >= 12 cm; percent slope of the plot area; site moisture conditions (e.g., riparian or upland area); dominant shrub and herb species, percent cover and estimation of heights. Up to ten adult trees are evaluated for DBH, height, crown loss, and disease agents and insects. In order to quantify the amount of insects or diseases present, the portion of the bole from the base of the tree to a height of 3.0 m is carefully evaluated for percent coverage of cankers, insect exit holes, conks, wounds, or any other disease or damage agents. One adult aspen randomly selected and cored for age and growth assessment Regeneration include stems $\leq$ 1.4m tall and < 12 cm DBH. Data collected concerning sapling species, damage agents present, stem status (live or dead), and age by destructive sampling one live regeneration stem from each of three regeneration size classes. Classes are defined by height and DBH as follows: small: 0.30 m - 1.4 m; medium: >0 - 3 cm DBH; large: >= 3 cm - 11.9 cm DBH. Data collected in the rapid assessment plots includes: percent mortality, average percent live crown, herbaceous species present, tree species present, percent slope, and stand aspect over an approximate 10 m x 30 m rectangle as seen from the road.

In: Adams, J. comp. 2010. Proceedings of the 57th Western International Forest Disease Work Conference; 2009 July 20-24; Durango, CO. Forest Health Technology Enterprise Team Fort Collins, CO

[1]Megan M. Dudley, Colorado State University
[2]William R. Jacobi, Dept. of Bioagricultural Sciences and Pest Management, Colorado State University
[3]Kelly S. Burns, USDA Forest Service, Rocky Mountain Region, Lakewood Service Center, Golden, CO

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Hogg, E.H., J.P. Brandt, & B. Kochtubajda. 2002. Growth and dieback of Aspen forests in northwestern Alberta, Canada, in relation to climate and insects. Canadian Journal Of Forest Research 32(5):823-32.

Hogg, E.H., J.P. Brandt, & M. Michaellian. 2008. Impacts of a regional drought on the productivity, dieback, and biomass of western Canadian aspen forests. Canadian Journal Of Forest Research 38(6):1373-384.

Worrall, J.J., R.A. Mask, T. Eager, L. Egeland & W.D. Sheppard. 2008. Sudden aspen decline in southwest Colorado. Phytopathology 98(6):S173.

Meg Dudley

Spatial and Ecological Analysis of Red Fir Decline in California Using FIA Data

Leif A. Mortenson[1]

Abstract

Red fir *(Abies magnifica)* is a high elevation conifer generally growing between an altitude of 1,400 and 2,700 meters. In California, red fir grows in the Sierra Nevada, the Klamath Mountains and in the southern Cascades. Red fir is a climax species, important to wildlife and can be managed for timber production. Red fir grows in mixed-conifer stands as well as pure stands and is often found in conjunction with white fir *(Abies concolor)*. Red fir is present in popular recreational areas including Yosemite, Kings Canyon, and Lassen Volcanic national parks as well as the Lake Tahoe region.

Increasing and higher-than-expected red fir mortality and decline in the Sierra Nevada over the past five years has been observed. I **hypothesize** that this study will also find increased rates of red fir mortality and decline across California. In addition, I **hypothesize**, due to my field observations, that the red fir population of northern California is considerably healthier than the red fir population of the central and southern Sierra Nevada. This mortality and decline is seen as being caused by a complex interaction of biotic, anthropogenic and abiotic factors. The abiotic factors include drought, climate change (especially decreased snowpack), and the effects of changing fire regimes. The anthropogenic factors include air pollution and forest management. The biotic factors, which vary more on a stand by stand basis, include Annosus Root Disease *(Heterobasidion annosum)* which I **hypothesize** to be significant, dwarf mistletoe *(Arceuthobium abietinum* f. *sp. magnificae),* Cytospora canker *(Cytospora abietis),* and the fir engraver beetle *(Scotylus ventralis)*.

Previously, the only broad spatial investigation at stand level on this topic has been done using remote sensing. Forest Inventory & Analysis (FIA) plots at a density of one every 3.4 miles across California will allow for both stand-level and spatial analysis across the entire red fir distribution zone in California. Drought stress patterns, air pollution, snowpack, and historical fires have all been mapped in California. My goal is to detect spatial patterns of mortality and decline through GIS that can contribute to better understanding of this complex interaction, and as ultimately find one of these abiotic, anthropogenic or biotic factors to be the most significant factor in this mortality and decline. Accomplishing this would allow for a better ecological understanding of the mortality and decline as well as help shape appropriate management strategies.

Background

Red fir *(Abies magnifica)* is a high elevation conifer growing between an altitude of roughly 1,400 and 2,740 meters (4,600 to 9,000 feet). In California, red fir grows in the Sierra Nevada, the Klamath Mountains and in the southern Cascades (Burns and Honkala 1990). Red fir is a climax species that is important to wildlife and can be managed for timber production. Red fir can grow in mixed-conifer stands as well as pure stands, and is often found in conjunction with white fir *(Abies concolor)*. Red fir is present in popular recreational areas including Yosemite, Kings Canyon, Sequoia and Lassen Volcanic National Parks, countless wilderness areas and the Lake Tahoe region.

USFS Forest Health and Protection (FHP) have observed increasing and higher-than-expected red fir mortality and decline in the Sierra Nevada over the past five years. (Bulaon and MacKenzie 2007) The Society of American Foresters (SAF) defines decline as the "decrease in trees, shrubs, and herbs, or forest health and vigor, caused by one or more biotic or abiotic factors" (www.safnet.dreamhosters.com

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In: Adams, J. comp. 2010. Proceedings of the 57th Western International Forest Disease Work Conference; 2009 July 20-24; Durango, CO. Forest Health Technology Enterprise Team Fort Collins, CO
[1]Leif A. Mortenson, Oregon State University, Forest Science Program, College of Forestry, USFS Pacific Northwest Research Station, Corvallis & Portland, OR

2009). My field observations from field work in the Forest Inventory and Analysis (FIA) program concur that red fir mortality is increasing. In addition, I have observed that the red fir population of northern California has considerably lower mortality rates than the red fir population of the Sierra Nevada. I have also observed mortality in young trees as well as old trees. This mortality and decline is assumed to be caused by a complex interaction of biotic, abiotic and anthropogenic (human caused) factors (Bulaon, MacKenzie, Pronos, Cannon personal communications, 2009). The suspected abiotic factors include drought (especially decreased snowpack), and the effects of changing fire regimes (especially increased severity), all of which have been associated with climate change. The direct anthropogenic factors include air pollution and forest management. The biotic factors, which vary more on a stand-by-stand basis include Annosus root disease *(Heterobasidion annosum)*, dwarf mistletoe *(Arceuthobium abietinum* f. *sp. magnificae),* Cytospora canker *(Cytospora abietis),* and the fir engraver beetle *(Scotylus ventralis)* (Bulaon, MacKenzie, Pronos, Cannon personal communications, 2009).

Hypotheses

Level one hypotheses are presumed to be highly likely due to my widespread observations and previous research (Bulaon and MacKenzie 2007; van Mantgem et al. 2009; Bulaon, MacKenzie, Pronos, Cannon personal communications, 2009) and are the building blocks for level two hypotheses. Additional level two hypotheses may be tested once data analysis begins.

Level one hypotheses

Rates of mortality and decline are increasing in red fir. Rates of mortality and decline are higher in the southern end of the red fir distribution zone (the middle and southern Sierra Nevada) than in the northern end (Klamath Mountains, southern Cascades and the northern Sierra Nevada).

Level two hypotheses

One of the aforementioned abiotic, anthropogenic or biotic factors will have a stronger **overall** spatial correlation with red fir mortality and decline than the other factors. Analyzing these data spatially will allow for the factors (for example; fir engraver, *H. annosum* and drought) most responsible for higher mortality and decline to be assigned at a **regional** or **local** level on a plot-by-plot basis.

Heterobasidion annosum is more widespread in the Sierra Nevada than previous reports have acknowledged. In addition, FIA may be under-coding (identifying and quantifying) *H. annosum.*

Goals

To provide forest managers, national park personnel and scientists with a more detailed understanding of the spatial distribution and causes of red fir mortality and decline in California.

To assess spatially, and from the field, the severity and distribution of *H. annosum* in California.

Objectives

Determine which abiotic, anthropogenic or biotic factors are the most significant broad factors in red fir mortality in California.

Work with OSU faculty and USFS Forest Science Lab (FSL) personnel on using FIA data to spatially quantify forest change over time.

Collaborate with FHP, Sonora, CA in gaining a better understanding of the specific ecological processes involved in this mortality for this project and their research.

Improve the coding of damaging agents in FIA data.
Assess mortality and decline over time to confirm that mortality and decline is indeed increasing and by what rate.

Produce an overview of red fir mortality by examining all damage types on red fir.

Produce useful maps created in ARCGIS for management decisions and further research by examining all inventoried mortality and decline geographically.

Rationale and Significance

Though vastly overshadowed in California by the concern given to Sudden Oak Death (SOD), increased red fir (and to some extent white fir) mortality has gained some attention. Conducting FIA surveys for the last three years has allowed me much observation of California's forests in detail. No mortality of any species, including SOD susceptible species, has rivaled the consistency of red fir mortality, especially in the Sierra Nevada. Bulaon and MacKenzie's 2007 report highlights their findings and concern (Bulaon and MaKenzie 2007) and J. Pronos (now retired pathologist) and S. Frankel (USFS Pacific Southwest Research Station) have been aware of this abnormally high true fir mortality in the Sierra Nevada for several years. P. Cannon (Regional Forest Pathologist, USDA FS PSW Region) has also expressed interest in this project.

Bulaon and MacKenzie (2007) and Pronos (2005) have evaluated FHP Aerial Detection Survey data in the central Sierra Nevada but this project will be the first to examine this specific mortality at such a broad scale. In addition, FIA data offers many more variables to analyze than does remote sensing data (aerial surveys or current LiDAR systems) data currently can. The FIA data will allow for spatial analysis of stand level data across the entire red fir distribution zone in California. The stratified random placement of FIA plots and a relatively high plot density (one plot roughly every three miles across forested conditions of all ownership in California) allow for significant inferences to be drawn.

The recently published and well publicized *Science* article *Widespread Increase of Tree Mortality in the western US* by van Mantgem et al. (2009) supports my hypothesis of increased mortality, although their study covers a broader area and time frame. They concluded that mortality in western old-growth forests had nearly doubled as a result of climate change. Although their findings are significant, they had relatively low plot density compared to FIA data. Furthermore, van Mantgem et al. (2009) did not focus on one species so there is a need for more species specific, regional research that addresses whether increased mortality is occurring.

Studies focusing on air pollution damage to forests have found that lower elevation forests (where red fir does not grow) are hardest hit in California. However, due to the extremely high levels of summer air pollution in the Sierra Nevada, I hesitate to quickly dismiss the hypothesis that air pollution is damaging red fir. Red fir is generally not the focus of fire ecologists, but Miller et al. (2008) present research on fire and red fir. They note that, "between 1984 and 2004 the annual burned area increased in moister, higher elevation forests dominated by firs but this trend was not true for drier mid to low elevation areas with yellow pines, i.e. stronger correlations between fire severity and climate for firs" (Miller et al. 2008). This highlights the increasing role that fire is playing in red fir forests and how management strategies may need to change.

Overlaying stand level FIA data (including insect and disease information) with drought/climate change projections, ozone pollution and fire regime data addresses stand level reactions to three major current issues in California's forests and California as a whole. In addition, red fir has the potential to be an indicator of major large scale concerns affecting the forests of California. Red fir's high elevation range, dependence on water from snow pack, as well as true (red) firs seemingly high susceptibility to pathogens and insects when stressed, make it an ideal indicator of change. Monitoring high elevation ecologic change, especially high mortality rates of one species is important as scientists try to quantify and provide solutions to the environmental changes that have resulted from the industrialized era.

Methods

On Plot: Plot level data collection techniques will (has) follow standard protocol for FIA plots (USDA Forest Service, 2008). FIA plots are placed using a stratified random inventory design. The plots are treated as if they are randomized. An important element of this project is gaining additional training (classes) here at Oregon State University as well as working with entomologist B. Bulaon, pathologist M. MacKenzie, other USFS, FHP professionals, and major professor/pathologist Dr. D. Shaw. This will have the added effect of improving accuracy of FIA data plus increasing our (my) awareness of factors that may not necessarily be required by FIA, yet are important in assessing forest health. A specific goal of additional field training is to assess the validity of our crew's initial diagnosis (and one of my hypotheses) that Annosus root disease (*H. annosum*) is extremely common in the Sierra Nevada. Time (safety) permitting, some additional investigating and photo documentation on plots containing red fir will occur. Taking root samples to be sent to the lab for analysis is likely on plots with significant decline.

Plot Data Techniques: Plots to be analyzed (hereafter referred to as red fir plots) in the project are currently defined as any plot with 20% of live and dead tree tally consisting of red fir. This is approximately 225 plots in California. All variables that are chosen for measurement can be viewed at each plot as a "snapshot" from the most recent inventory or by measurement of the differences (change over time) between inventory visits. The underlying goal once plot data analysis techniques are finalized is to **rate (create an index) each plot for severity (or lack) of mortality and decline and note the specific types of damages** (type of root disease, mistletoe, dead top etc.) each plot is experiencing.

An initial technique will simply be to examine all red fir damage data. This will provide insight into which analysis approaches will be most appropriate. Quantifying differences in mortality between plot visits/measurement (5 years on USFS plots and 10 years on plots of all other ownership) will be necessary. The best method for calculating rates of mortality is unknown at this time. As more FIA plots are remeasured using the exact same plot layout (USDA Forest Service, 2008) it appears that mortality calculation will improve but this is only just becoming possible. Prior to 2001 a different plot layout was used, so though the location of plots and most plot variables were the same, change-over-time comparisons using these data are much less precise. I will work with Dr. A. Gray on this issue after my field season concludes.

Total live and dead basal area (measured as basal area feet squared per acre) will be calculated. A statistically significant increase in dead red fir basal area from one inventory (measurement) to the next will indicate increasing decline. Designing a method of identifying dying red fir (from existing data) will occur. This will become the second technique for measuring decline. This is of great importance as many red fir appear to be "greatly suffering" but are not dead. In order to be classified as a "greatly suffering" tree (i.e. measurement of decline), it will have to have a certain number of pre-selected damage agents, for example bark beetles are coded 01 and Annosus root disease is coded as 64 and has a severity rating of one (low) to three (high) etc. In addition, this will help avoid bias by "offsetting" errors and the fact that different crews may code damages differently ways. For example fir engraver and *H. annosum* are probably both present but a crew will code one or the other since it's difficult to visually see damage of either since *H. annosum* conks are below ground and beetle evidence is often 15 feet up the bole. Measuring to see if there is an increase in (basal area feet squared per acre) recently fallen coarse woody material (debris) can give a third estimate of decline. All coarse woody material is assigned a decay rating from one (sound, freshly fallen, intact logs) to five (soft; powdery when dry) (USDA Forest Service, 2008).

Comparing the rates of red fir mortality and decline with other species that are often found at similar elevations can validate that red fir mortality and decline is unusual. If increased mortality rates are found in other species then this would support the findings of van Mantgem et al. (2009) that show greatly increased mortality rates across western forests.

Regional Geospatial Data: Special analysis will be performed by importing all red fir plots into ARCGIS. Each red fir plot will be overlaid with data layers showing spatial patterns of the following:

Air pollution (focusing on ozone) using air quality index data, see available data sets in Bytnerowicz,et. al 2003.

Climate/Drought using SNOTEL (annual snow pack monitoring sites located in the Sierra Nevada) data and additional data sets quantifying drought and change (many possible sets exist, finding the optimal set will be a necessity, the Palmer Drought Severity Index is likely).

Fire Regime using historical records/maps, fire regime condition class, as well as current FIA fuel loading data (USDA Forest Service, 2008).

Pathogen presence, absence, severity, using (already collected) FIA data.

Insect presence, absence, severity, using (already collected) FIA data.

After viewing data in ARCGIS, statistical analysis will begin and **correlations between mortality and decline and regional geospatial data will be evaluated.** The exact method is not yet determined, as potential techniques need to be thoroughly examined. Using ARCGIS, presumably the geostatistical extension is likely in addition to some form of autocorrelation analysis. Additionally, regression or multivariate analysis and perhaps additional evaluations using Dr.s M. Betts and A. Gray's expertise will be incorporated.

Expected Results and Interpretations

Analyzing live versus dead basal area and change between inventories (measurements) and recently fallen coarse woody material for the whole red fir distribution zone can be performed in a statistical program. My level one (broad) hypothesis that red fir mortality and decline is increasing throughout California can also be tested in a statistical program. Increased dead basal area, heavily suffering rated trees and recently fallen coarse woody material will support my hypothesis of decline.

Maps created in ARCGIS will be able to support my level one (broad) hypothesis that red fir mortality and decline is higher in the Sierra Nevada than in the more northerly Cascade and Klamath Mountains.

A form of autocorrelation analysis and the ARCGIS geostatistical extension will quantify the correlation between red fir mortality and decline spatially across the entire red fir distribution zone. This can prove my number one and two level two hypotheses (see hypothesis section) which aim to find significant spatial correlation between red fir mortality and decline and a specific abiotic, anthropogenic and biotic factor that will be tested.

Maps will be created for specific regions including the west central Sierra Nevada area that my FHP collaborators are focusing on.

Examining my data set cannot necessarily test my hypothesis that Annosus root disease is more widespread in the Sierra Nevada than previous reports and inventories have reported. This will be roughly accepted through fieldwork with major professor D. Shaw and field training with FHP collaborators.

Scope of Inference

Due to the stratified randomized nature of FIA plots and the number of plots, (roughly 225) the scope of inference will be the entire red fir population of California.

Pitfalls and Limitations

If red fir mortality and decline is not found to be increasing through FIA data (unlikely) then many parts of the project will not be able to be performed. FHP collaborators have found increased red fir mortality in the west slope of the central Sierra Nevada. If my results for all of California differ, then some elements of my research, especially collaborating with FHP will not be possible.

There is no way to quantify the quality of FIA data, especially prior to 2006 when a much greater number of crews (i.e. greater chance of biased data) worked in the same area compared with the current situation when only a few crews work in the red fir distribution zone. My technique of identifying dying red fir based on a number of pre-selected damage codes will limit the effect of incorrectly identified damages.

There will be no way of quantifying if FIA has been "under-coding" Annosus root disease even if it is suspected after fieldwork with D. Shaw and FHP personnel.

Timeline

Spring/Summer ’09: fieldwork
Fall ’09: classes & limited analysis
Winter ’10: analysis
Spring ’10: classes & limited analysis
Summer ’10: fieldwork
Fall/Winter ‘10/’11: analysis & thesis writing

Budget

This will be a Joint Venture Agreement, OSU will contribute tuition.
Graduate Research Assistant (GRA, .49)
OSU costs (5 quarters)
GRA: $27,950
OPE: $3,342
Total: $31,292
$3,500 for meetings, conferences, travel, publication costs, POV travel for additional observation.

TOTAL: $34,792

Leif A. Mortenson

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Poster Abstracts
Moderated by Meg Dudley

"Limber Pine Health Survey in the Rocky Mountains and North Dakota."
James T. Blodgett, Kelly S. Burns, Brian Howell, Marcus Jackson, William R. Jacobi, & Anna W. Schoettle

"The Geographic Distribution of Red Fir and Noble Fir Based on Infection by Pacific Silver Fir Dwarf Mistletoe."
Carolyn M. Daugherty & Robert L. Mathiasen

"The Forest Insect and Pathogen Hazard Rating System Database."
Andrew J. McMahan & Eric L. Smith

"Characterization of partial resistant western white pine trees against white pine blister rust using in vitro screening techniques."
D. Noshad, J. N. King, R. Sturrock & A. K. M. Ekramoddoullah

"Induced Fruiting of *Phellinus sulphurascens*."
Kevin W. Pellow & Rona N. Sturrock

"Swiss Needle Cast of Douglas-Fir in Oregon and the Swiss Needle Cast Cooperative."
David Shaw, Travis Woolley, Alan Kanaskie, Douglas Maguire & Greg Filip

Limber Pine Health Survey in the Rocky Mountains and North Dakota

James T. Blodgett[1], Kelly S. Burns[1], Brian Howell[1], Marcus Jackson[2], William R. Jacobi[3] and Anna W. Schoettle[4]

Limber pines are widely distributed across the Rocky Mountains and are especially important because of their unique cultural and ecological characteristics. Recent surveys have suggested that significant ecological impacts are occurring as a result of white pine blister rust (WPBR) and other damaging agents. Additionally, several new WPBR infestations have been discovered in Colorado and the disease front in northern Colorado is within 6 miles of Rocky Mountain National Park. Past studies have provided critical information on the distribution and intensity of the disease, but we have little information on the long-term changes that will result from this invasive disease.

The purpose of this study is to assess the long-term ecological health of limber pine within WPBR-infested and threatened areas of the Rocky Mountains and to provide baseline information necessary to sustain, protect, and restore limber pine stands in the Rocky Mountains and North Dakota. A total of 83 permanent plots (50 X 200 feet) were established and 119 variables were recorded to characterize sites, trees, regeneration, and understory vegetation. In 2006, 36 plots were installed in northern Colorado and southern Wyoming. In 2007, 29 plots were installed in central and western Wyoming, 16 plots in central Montana, and 2 plots in North Dakota. Plots contained 13 to 197 trees, comprised of 8 to 169 limber pine. The elevation of the plots ranged from 2,881 to 10,243 feet. Very few trees had dwarf mistletoe or mountain pine beetle with an average plot incidences (API) of infected/infested trees of 4% and 3%, respectively. Many trees had twig beetles (API 35%), however damage was minor. WPBR was found in 81% of the plots (API 35%) with higher API of WPBR in the north, except for North Dakota where WPBR was not found. The API of WPBR was 29% in northern Colorado/southern Wyoming, 37% in central/western Wyoming, and 49% in central Montana. Additional periodic surveys are planned to monitor long-term ecological impacts.

Bill Jacobi

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The Geographic Distribution of Red Fir and Noble Fir Based on Infection by Pacific Silver Fir Dwarf Mistletoe

Carolyn M. Daugherty[1] and Robert L. Mathiasen[2]

The distribution of red fir (*Abies magnifica* A. Murray) and noble fir (*Abies procera* Rehder) in Oregon has long been debated. Some investigators contend that noble fir is distributed from central Washington through Oregon into northwestern California. Others maintain that noble fir is restricted to a smaller range from central Washington to central Oregon. The objective of this study was to determine if selective parasitism of red fir and noble fir by Pacific silver fir dwarf mistletoe (*Arceuthobium tsugense* (Rosendahl) G.N. Jones subsp. *amabilae* Mathiasen & C. Daugherty) could be used to provide additional data supporting one of the geographic distributions proposed for these true firs.

The research was conducted in the central Cascade Mountains of Oregon. A total of 11 stands in Oregon infested with Pacific silver fir dwarf mistletoe were sampled to compare host susceptibility to this parasitic plant. At each of 11 study areas, 10 temporary circular plots with a 6-m radius (0.012 ha) were placed around large, severely infected Pacific silver firs. Each live tree greater than 1.4 m in height in the plots was examined and the following data were collected: species, diameter, and dwarf mistletoe rating (6-class system). Incidence of infection of Pacific silver fir, noble fir, and mountain hemlock was summarized for each study area. Six of the study areas were north of 44^{o} N and five were south of this latitude.

Pacific silver fir and noble fir were principal hosts of Pacific silver fir dwarf mistletoe in Oregon, but red fir was immune to this dwarf mistletoe there. Populations of true firs morphologically resembling noble fir south of latitude 44^{o} N in Oregon were immune to infection by Pacific silver fir dwarf mistletoe. Populations of noble fir north of latitude 44^{o} N in Oregon were principal hosts of Pacific silver fir dwarf mistletoe.

The complete immunity of red fir and trees morphologically resembling noble fir to Pacific silver fir dwarf mistletoe south of approximately latitude 44^{o} N in Oregon supports the classification of these true fir populations as red fir, and not noble fir. The severe parasitism of trees resembling noble fir by Pacific silver fir dwarf mistletoe north of latitude 44^{o} N in central Oregon supports the classification of these populations as noble fir. These findings agree with earlier morphological and chemical investigations of these true fir populations that also indicated noble fir (sensu stricto) is distributed in the Cascade Mountains north of latitude 44^{o} N. These results provide the best example of using dwarf mistletoe host specificity as evidence to distinguish between different interpretations of the geographic distribution of their coniferous hosts.

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The Forest Insect and Pathogen Hazard Rating System Database

Andrew J. McMahan[1] and Eric L. Smith[2]

The Forest Insect and Pathogen Hazard Rating System Database is a collection of detailed summaries of over 500 North American insect and disease hazard and risk models and citations organized in a Microsoft Access relational database. The rating systems estimate some measure of risk or hazard to forest stands or trees from one or more insect or pathogen agent. For each model, the database catalogues information about its spatial scope; input and output variables; applicable host trees; and applicable geographic range, among other model attributes and descriptions. Also included are details about each model's documentation, including a thorough cataloging of seminal and related citations. The database includes hyperlinks to citations available online, as well as to online web pages discussing pests and hosts. Also included are electronic copies (PDFs) of over 200 of the cited documents. A built-in report generator allows users to easily query the database to retrieve reports describing models and/or citations of interest, with queries being based on any combination of (1) pest agent or agent guild; (2) agent host(s); (3) geographic area; or (4) author. The catalog includes all of the 2006 National Insect and Disease Risk Map (NIDRM) models.

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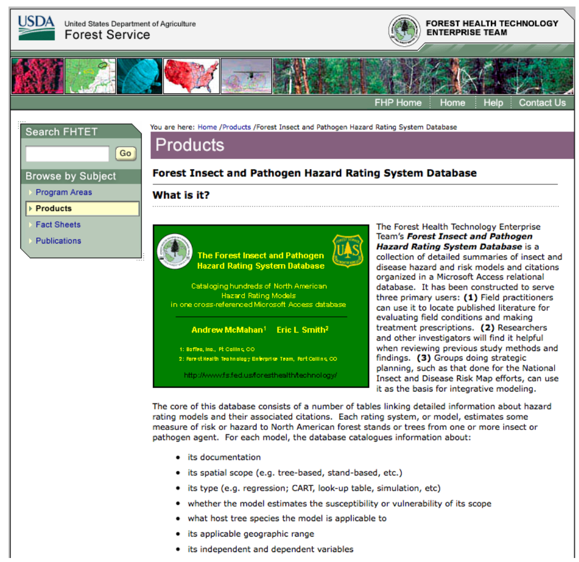
The Forest Insect and Pathogen Hazard Rating System Database is made available by the Forest Health Technology Enterprise Team and is available for free on the web at:
http://www.fs.fed.us/foresthealth/technology/haz_rating_database.shtml



Characterization of Partial Resistant Western White Pine Trees Against White Pine Blister Rust Using *In Vitro* Screening Techniques

D. Noshad[1], J.N. King[2], R. Sturrock[3], A.K.M. Ekramoddoullah[4]

White pine blister rust caused by *Cronartium ribicola* J.C. Fischer has been a major problem in white pine plantations across North American forests. *Cronartium ribicola* J.C. Fisch. ex Rabenh. is one of the most destructive forest pathogens of North American white pines. The pathogen infects pine trees through their stomata. Then it colonizes in the stem and produces canker on the stem in the next growing season. Different methods of screening have been used to characterize resistance against the disease.

Although this exotic disease has been devastating to many populations of our native white pine species since its introduction a century ago, significant number of partial resistant plants have been identified. A major group of partial resistant plants in British Columbia, Canada, described as difficult-to-infect (DI), presented a significant resistance in our field trials. We developed a disease assessment index, based on both *in vitro* and *ex vitro* techniques, to evaluate specific reactions to the pathogen of the DI plants. The preliminary results from our DI screening experiments indicated a significant difference in the number of successful infections between DI and control populations. Further morphological investigation into the mechanism(s) responsible for these variations with electron microscopy revealed a considerable difference in the morphology of stomata. Also, the amount of epicuticular wax on the stomata of the resistant populations was significantly higher than the control plants. These adaptations could provide a greater structural defence system against white pine blister rust.

Keywords: structural defence mechanism, five needle pine, *Pinus monticola*, disease resistance, tissue culture, SEM, microscopy

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Induced Fruiting of *Phellinus sulphurascens*

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Phellinus sulphurascens Pilát (syn. *P. weirii* (Murrill) Gilb.) is an important root pathogen in the western forests of Canada and the USA. In nature, sporophore formation by *P. sulphurascens* is rare and inconsistent. Recently, molecular methods have been used to study mating and phylogenetic relationships in this and other *Phellinus* species. To facilitate our understanding of the genetics of *P. sulphurascens* we developed a method to initiate fruit body formation as a means of obtaining single spore cultures.

In the spring, sterilized stem sections of red alder (*Alnus rubra* Bong.) were placed in mushroom spawn bags (Unicorn Bags, Garland, Texas) and each bag was inoculated with a liquid culture of one of several isolates of *P. sulphurascens* collected in British Columbia (BC). In the fall (after ~ 6 months), once the stem pieces were sufficiently colonized, one side of the bag was cut away and this open side of exposed blocks was placed over plastic bins containing moistened peat moss in a shade house under ambient conditions at the Pacific Forestry Centre, Victoria, BC (48.459^{o} N, -123.396^{o}W). A plastic sheet was placed over the bags to maintain a high relative humidity. Temperatures during this September to October time period averaged 15^{o}C for the high and close to 10^{o}C for the low. Some isolates began forming sporophore tissue within days of placement, while others took several weeks before this occurred. During mid-October, the majority of isolates began forming sporophore initials. On average, it took two weeks from the time of this initial formation until sporulation occurred. Variation in timing of these reproductive phases was noted amongst the isolates we used. After 4 months, 35 out of 51 isolates (68%) had formed fruiting tissues and spore collections were made from a subsample of the isolates.

Additional trials that we have conducted have shown that, in our climate region, *P. sulphurascens* fruiting can also be successfully induced during the spring months (i.e., February-May) when temperatures approximate those of our fall; to the best of our knowledge, *P. sulphurascens* has been documented to only form fruiting structures in the fall in natural settings. Subsequent to these initial trials, we tested this induction method on other *Phellinus* species; sporulation was obtained with several isolates of *P. weirii* (formerly known as the cedar form of *P. weirii sensu lato*), an isolate of *P. nigrolimitatus* (Romell) Bourdot and Galzin, and with a Japanese isolate of *P. sulphurascens*. We are continuing with a variety of sporophore induction trials.

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Swiss Needle Cast of Douglas-Fir in Oregon and the Swiss Needle Cast Cooperative

David Shaw[1], Travis Woolley[1], Alan Kanaskie[2], Douglas Maguire[1] and Greg Filip[3]

Swiss Needle Cast (SNC) is a foliage disease of Douglas-fir (*Pseudotsuga menziesii*) caused by the ascomycete fungus *Phaeocryptopus gaeumannii*. Currently it is causing an epidemic west of the Oregon coast range from Coos Bay to Astoria, with a 2008 aerial survey estimate of over 350,000 acres of plantations with visible symptoms. The disease occurs in adjacent coastal Washington, but is not being surveyed. General symptoms include chlorotic needles, decreased needle retention resulting in sparse crowns, and reductions in growth. Growth losses in the area of epidemic have been in the range of 20-55%, while mortality from the disease is rare. The Swiss Needle Cast Cooperative (SNCC) was established in January 1997 with University, Industry, and State and Federal partners. The mission of the SNCC is to conduct research on enhancing Douglas-fir productivity and forest health in the presence of Swiss needle cast. Current research is focused on silvicultural tools to improve management of the disease, as the biology of *P. gaeumannii* has been a previous focus.

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An integrated pest management strategy is continually being improved, and currently focuses on; 1) using aerial survey data and stand hazard rating models to determine potential impacts of the disease for a given site, 2) quantitative stand assessments which use ORGANON growth modeling to determine deviation from normal growth, 3) use of tested silvicultural systems, 4) tree improvement through the Pacific Northwest Tree Improvement Cooperative, and, 5) continued research, monitoring, and long-term planning.

David Shaw

Panels

Panel: Aspen Health

"Diseases and Insects Associated With Sudden Aspen Decline in Southwestern Colorado."
Suzanne Bethers, Jim Worrall & Tom Eager

"Aspen Condition in Northern Wyoming and Western South Dakota."
James T. Blodgett & Kurt K. Allen

"Monitoring the Condition of Aspen in the Northern and Intermountain Regions."
John C. Guyon II, James T. Hoffman, Holly Kearns & Brytten Steed

"Cytospora Canker Complex on Colorado's Aspen."
Jeff Kepley, Brent Reeves & Gerry Adams

Panel: Back to the Future: New and Historical Perspectives on Wood Decays

"Decay of Fire-Killed Western Larch."
Marcus Jackson

Panel: High Elevation Forest Declines

"Balsam Woolly Adelgid – an Emerging Architect of High Elevation Forests in the West."
Kris Chadwick, Lia Spiegel & Connie Mehmel

"Subalpine Fir Decline in Southern Idaho." Laura Lazarus

"Whitebark Pine Restoration Program – History and Progress."
John Schwandt & Holly Kearns

Panel: New Pathogens: Are We Up the Creek Without Our Paddle?

"*Phytophthora pinifolia* on *Pinus radiata* in Chile."
Phil Cannon

"Determining if There are Lines of Guava Rust (*Puccinia psidii*) That Could Seriously Impact Ohia (*Metrosideros polymorpha*), in Hawaii."
Philip G. Cannon, Acelino Couto Alfenas, Rodrigo Garca Neves, Mee-Sook Kim, Tobin Peever & Ned Klopfenstein

"Pests- Pacific Rim & Beyond-Identifying New Potential Pathogens." Will Littke

"A National View…Early Detection Rapid Response (EDRR), FHM Evaluation Monitoring, and EXFOR and Risk Analysis."
Bruce Moltzan

Panel: White Pine Blister Rust

"White Pine Blister Rust in the Interior Mountain West."
Kelly Burns, Jim Blodgett, Dave Conklin, Brian Geils, Jim Hoffman, Marcus Jackson, William Jacobi, Holly Kearns & Anna Schoettle

"White pine blister rust on new telial hosts (*Castilleja* and *Pedicularis*) in whitebark pine ecosystems at Mt. Rainier and Crater Lake National Parks."
Robin Mulvey

Diseases and Insects Associated with Sudden Aspen Decline in Southwestern Colorado

Suzanne Bethers[1], Jim Worrall and Tom Eager

Introduction

The rapid, widespread mortality and branch dieback of quaking aspen (*Populus tremuloides*) was first noticed in SW Colorado in 2004 and has become a significant regional issue (Worrall et al. 2008, Fairweather et al. 2008, Bartos 2008). This was termed "sudden aspen decline" or SAD. This decline is distinguished from other aspen declines noted in the literature by its rapidity, its wide distribution, the mortality of both crown and root systems, and a low rate of regeneration. The predisposing factors linked to SAD include open stands at lower elevations on exposed slope positions and southerly aspects (Worrall et al., 2008). The inciting factors are hypothesized to be acute drought accompanied by warmer growing seasons. Contributing factors include insects and diseases which attack already weakened trees known as secondary agents.

Initial observations showed that secondary agents were frequently observed in SAD stands, the five most dominant were: Cytospora canker (usually caused by *Valsa sordida*), two wood borers (bronze poplar borer (*Agrilus liragus)* and poplar borer *(Saperda calcarata*)), and two aspen bark beetles (*Procryphalus mucronatus* and *Trypophloeus populi*) (Worrall et al., 2008). These are considered secondary agents, attacking trees already weakened by another environmental stressor. Those agents that are cited as the common mortality agents of aspen in Colorado, mottled white root rot (*Ganoderma applenatum*) and sooty bark canker (*Encoelia pruinosa*) were not typically observed within the SAD stands.

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We used these observations to form our hypotheses for this study: (1) secondary agents are the main agents involved in the mortality of SAD stands, (2) secondary agents increase the rate of mortality in SAD stands, (3) the same contributing and inciting factors correlated with crown loss are correlated with the frequency of SAD agents.

Methods

We conducted a study of damaged and healthy stands in four national forests of southwestern Colorado including the Grand Mesa, Uncompahgre, and the Gunnison National Forests (GMUG) as well as the Dolores-Mancos district of the San Juan National Forest. The aerial survey of damaged aspen from 2006 and 2007 were used to select points of damaged stands. A point in an adjacent healthy stand was selected for comparison (>200 m from damaged stand. This paired plot selection was meant to eliminate coincidental factors (like those frequently observed with changes in elevation) and focus on site factors unique to damaged plots. Damaged plots were defined as >25% recent crown loss (RCL), while healthy stands were defined as having ≤25% RCL.

Once points were established, plots were surveyed for site factors, stand variables, and damage agents. This included slope position, aspect, elevation, basal area, tree height, and tree age. Live and recently dead trees were surveyed for all damage agents present such as borers, cankers, rots, defoliators, animal damage, and abiotic damage.

Results and Discussion

Those secondary agents that were initially observed in SAD stands, including Cytospora canker, *Agrilus*, aspen bark beetles, and *Saperda,* were significantly more frequent in damaged plots than in healthy plots (Figure 1). *Phellinus tremulae* was also common, but similarly frequent in damaged and healthy stands.

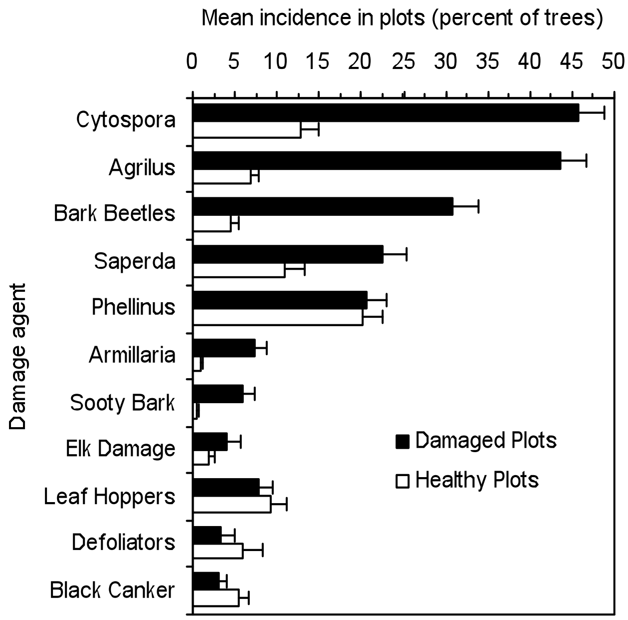

Figure 1. Mean incidence of damage agents (% of trees in plots affected) in healthy and damaged plots. 162 plots included. Error bars indicate standard errors.

This indicated that *Phellinus* does not play a primary role in SAD. Armillaria root rot and sooty bark canker had a significantly higher frequency in damaged plots compared to healthy plots, but the overall frequency was much lower. The remaining major damage agents were at low frequencies and demonstrated no significant differences between damaged stands and healthy stands. They are, therefore, unlikely to be major factors in SAD. Additional damage agents found within stands at low frequencies (<1% incidence on average) included galls, white mottled root rot, cryptospheria canker, hypoxylon canker, sunscald, abiotic damage, and human damage.

SAD associated agents tended to co-occur (Table 1). *Agrilus*, Cytospora canker, and bark beetles had the highest correlation coefficients and are the most significant. Armillaria was significantly correlated with these three agents but with lower correlation coefficients. Sooty bark canker was also significantly correlated with *Agrilus* and bark beetles. *Saperda*, perhaps surprisingly, was only weakly correlated with bark beetles and Cytospora canker. This may suggest that *Saperda* targets a different subset of stand characteristics from Cytospora canker, *Agrilus* and bark beetles.

Correlations between the major damage agents and site and stand factors also show the top three SAD agents as being most strongly associated with the characteristics of SAD stands including root mortality, recent crown loss and tree slenderness (also site index and tree height, *not shown*). This would indicate that these three agents are indeed most strongly associated with SAD. *Saperda* and sooty bark canker were not significantly correlated with root mortality, but were associated with crown loss, perhaps indicating more affect on the overstory component. *Armillaria* showed a weaker correlation with stand characteristics, but followed trends similar to the top three SAD agents. Sooty bark canker was unique in its positive correlation with higher moisture sites and lower shrub cover. The spotty correlation of moisture index, basal area, and shrub cover, shows these factors to be somewhat important, but perhaps not as much as other measures of site quality such as tree slenderness.

Table 1. Pearson correlation coefficients among agent incidence in plots. N=162 plots

	Cytos	Agrilus	BrkBtls	Armllria	StyBrkCkr	Saperda	PhlnsTrm
Agrilus	**0.57*** **						
BrkBtls	**0.59*** **	**0.64*** **					
Armllria	**0.38*** **	**0.40*** **	**0.34*** **				
StyBrkCkr	0.03	**0.37*** **	**0.26*** **	0.09			
Saperda	**0.20***	0.09	**0.16***	0.04	-0.04		
PhlnsTrm	-0.11	-0.07	-0.12	0.07	0.06	**-0.16***	
LfHops	-0.09	-0.08	0.01	**-0.17***	-0.06	-0.02	-0.02
*	p≤0.05	**	p<0.01	***	p<0.001		

Table 2. Pearson correlations coefficients of damage agents and site and stand factors. N=160 plots

Plot characteristics	Agrilus	Bark Beetles	Cytospora	Armillaria	Saperda	Sooty Bark
Root Mortality	0.42***	0.35***	0.38***	0.16*		
Recent Crown Loss	0.79***	0.64***	0.68***	0.20**	0.45***	0.27***
Tree Slenderness	-0.30***	-0.35***	-0.34***	-0.23**	-0.19*	
Moisture Index2002			-0.17*	-0.16*		0.23**
Basal Area		-0.21*	-0.17*		-0.29***	
Shrub Cover					0.25**	-0.19*
*	p≤0.05	**	p<0.01	***	p<0.001	

The top four SAD agents differed in their relationships to crown loss (Figure 2). The incidence of Cytospora canker increased linearly (at a slope of 0.9) with recent crown loss in both healthy and damaged stands. This suggests no limitation of inoculum within stands, as well as rapid decline of trees with *Cytospora* infection. The incidence of *Agrilus* in healthy plots is significantly lower than in damaged plots indicating a lower of population of *Agrilus* in healthy plots (Figure 2b).

Also, relative to Cytospora canker, *Agrilus* had a weaker or slower impact on crown loss, indicated by the slope of the damaged and healthy line. Bark beetles were also less frequent in healthy plots compared to damaged plots. However the increase in frequency vs. crown loss was exponential. This indicates both a limited beetle population in healthy stands as well potentially some aggressive movement of bark beetles into trees with lower crown loss within sick stands. The shape of the sick curve may also indicate bark beetles having a significant effect on tree mortality with bark beetles and crown loss rising steeply together. Of course, there are two species of bark beetles, with different habits and targets. It may be that the population of *Trypophloeus populi*, which infests green bark, is nearly absent in healthy stands. *Procryphalus mucronatus*, which targets dead bark, most likely occurs in mainly dead trees of both healthy and damaged stands. The incidence of *Saperda* vs. crown class (Figure 2d) contrasts with that of the other major damage agents. *Saperda* was more frequent in damaged plots than in healthy plots, but the slope of the line is nearly flat, indicating that *Saperda* has little immediate effect on crown loss or perhaps a delayed effect.

Conclusion

Five agents were found at higher frequencies in damaged plots than in healthy plots: Cytospora canker, *Saperda* (poplar borer), *Agrilus* (bronze poplar borer), aspen bark beetles (*Procryphalus* and *Trypophloeus*), Armillaria root disease, and sooty bark canker.

Bark beetles, Cytospora canker, and *Agrilus* had the most significant associations with crown loss, root mortality, and SAD site conditions such as lower elevations, and drier, shorter, more open stands. They are also found associated together within plots. *Saperda* apparently acts within SAD stands to limited effect. It targeted SAD stands preferentially, but was not limited to them. Conclusions about Armillaria root disease are limited to dead and dying trees, as we did not check live, healthy trees for *Armillaria.* It is weakly associated with root mortality and crown loss, as well as SAD stand factors such as stout trees and dry sites. More data needs to be collected to clarify its association and role in SAD.

Sooty bark canker was not common but was more frequent in damaged than in healthy plots. It is significantly associated with crown loss, but not root morality. It's also associated with wetter, more closed canopy sites, and on older larger trees. We found it to be predominantly at elevations of 9000-9500 ft. These associations separate sooty bark canker as perhaps overlapping with SAD stands, but not playing a broad role in SAD.

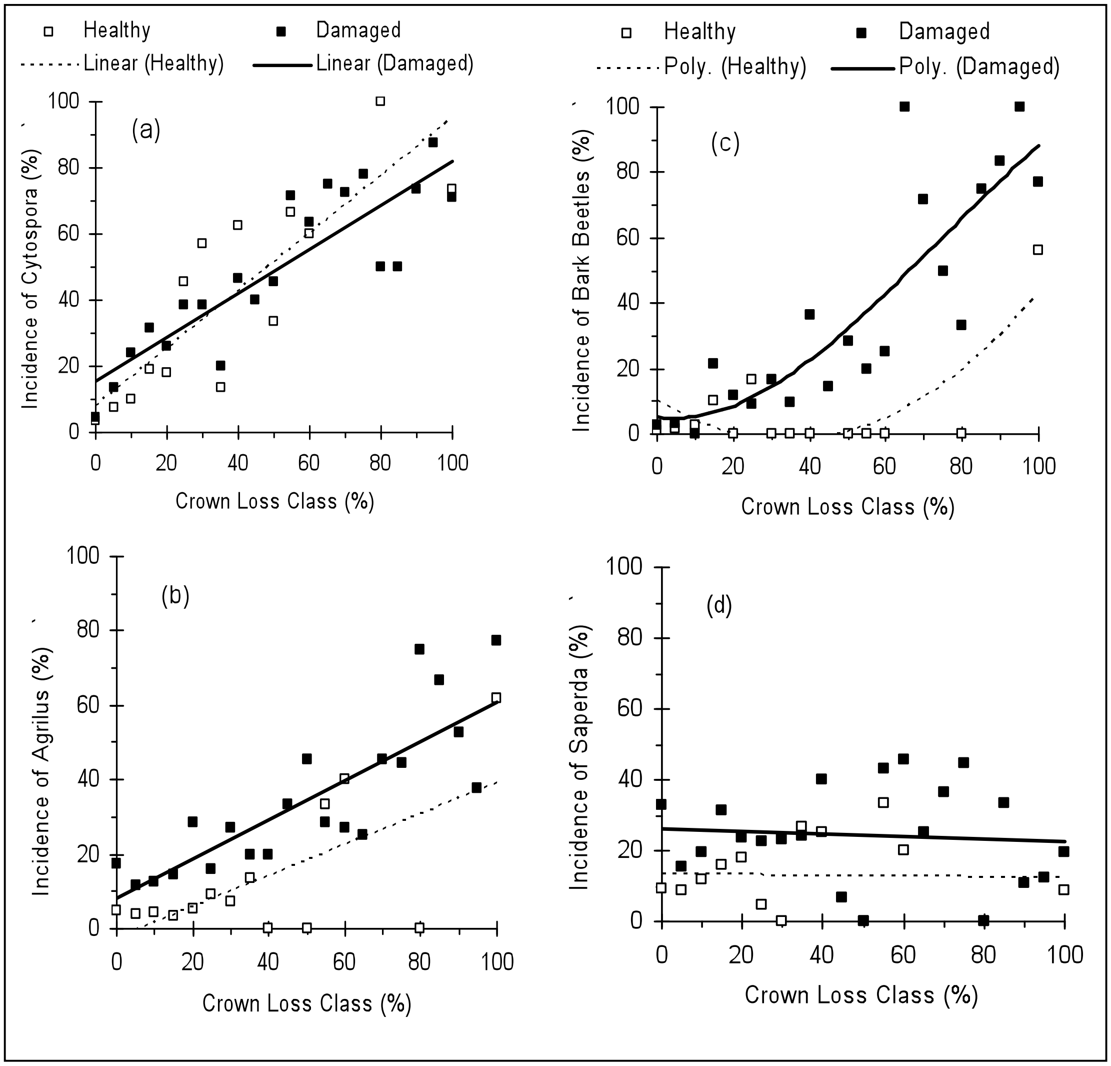

Figure 2. Incidence of the top four agents vs. the Crown Loss Status of trees in Healthy and Sick plots. n= 2240 live and recently dead trees.

Suzanne Bethers

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Aspen Condition in Northern Wyoming and Western South Dakota

James T. Blodgett[1] and Kurt K. Allen[1]

Introduction

Aspen is an important and widely distributed species in the Rocky Mountains and Black Hills. Aspen forests support diversity, wildlife, watersheds, aesthetics, and local economies. Aspen decline and mortality has been reported from aerial detection surveys, field surveys, forest managers, and the public over the past years in Colorado and Wyoming. Unfortunately, information obtained from aerial surveys can not quantify the extent and severity of decline and mortality, enumerate the condition of regeneration, or catalog specific causal factors. Knowing the distribution, severity, and frequency of causal agents is required before appropriate disease management recommendations can be made.

The objectives of this study are to evaluate tree and regeneration health, quantify frequencies of damage causal agents, generate hazard maps of the extent and severity of the aspen condition, and analyze the maps in relation to aerial detection and remote sensing surveys, precipitation, other weather factors, and other surveys.

Materials & Methods

A series of permanent plots were established systematically in aspen stands (≥ 50% aspen; ≥ 2 acres) in the Black Hills and Shoshone National Forests in 2008. Three circular plots were established in each stand for both trees (1/50 acre) and for seedlings/saplings (1/500 acre). A minimum spacing between plots of 40 meters was used for both tree and regeneration plots.

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At each plot center, site information was recorded including coordinates, elevation, stand age, slope position, slope, and aspect.

Root disease pathogens were assessed on a per plot basis by examining trees within 40 meters of plot centers. Armillaria was recorded as found or not found based on examining 3 recent dead aspen trees per plot for the presence of mycelial fans and/or rhizomorphs. If Armillaria was found on the dead aspen, 2 live aspen trees per plot were then examined. Armillaria root disease was recorded as found or not found if mycelial fans were observed in the cambium or phloem of a live tree. Ganoderma root disease (*G. applanatum*) was recorded as found or not found based on an examination of 10 trees per plot for the presence of Ganoderma conks.

Variables recorded for all trees included species, tree diameter (DBH), and health status (living, recent dead, old dead). For aspen trees, crown health (percentage live crown) was estimated. For seedlings and saplings, species and health status (live/dead) was tallied. All associated damage agents (diseases, insects, damage) were recorded for aspen trees (live/recent dead), seedlings, and saplings.

Results

Three hundred and thirty permanent plots were established in the Black Hills and Shoshone National Forests in 2008. The average live crown of trees was 88%, an average tree mortality rate was estimated at 4% per year, and aspen regeneration averaged 3,450 stems per acre.

Twenty-six different damage agents were recorded on aspen trees. However, only seven agents were observed on more than 2% of the trees. Damage agents that were observed on more than 2% of the trees were as follows: Cytospora canker (*C. chrysosperma*; 39%); sooty-bark canker (*Encoelia* *pruinosa*; 26%); aspen trunk rot (*Phellinus tremulae*; 14%); bronze poplar borer (*Agrilus liragus*; 11%); black canker (*Ceratocystis fimbriata*; 8%), Cryptosphaeria canker (*C. lignyota*; 4%); and poplar borer (*Saperda calcarata*; 4%). Sooty-bark and Cryptosphaeria cankers are difficult to differentiate visually when cankers are young.

Twenty seven damage agents were recorded on aspen regeneration. However, only two were observed on more than 2% of the regeneration. Damage agents that were observed on more than 2% of the aspen regeneration were animal browsing (19%) and Cytospora canker (*C. chrysosperma*; 6%).

Two root diseases were detected in the plots. *Armillaria* spp. were found in 53% of the plots and were confirmed to be causing root disease in 14% of the plots. Ganoderma root disease was found in 13% of the plots.

Conclusions

Most of the aspen stands in the Black Hills and Shoshone National Forests are healthy and regenerating, although a few stands have significant mortality. Many causal agents were observed, but only 8 agents were observed on more than 2% of the trees and regeneration. Animal browsing was by far the most common damage on regeneration, but competing tree species and shading from overstory trees likely are the main factors affecting regeneration. Additional plots are being established and a thorough analysis of the data is planned when the field surveys are complete.

Monitoring the Condition of Aspen Forests in the Northern and Intermountain Regions

John C. Guyon II[1], James T. Hoffman[2], Holly Kearns[3] and Brytten Steed[4]

Since the 1970's, forest, range, and wildlife managers in the Intermountain and Northern Rocky Mountain Regions documented a decline in total aspen acreage and health within western forests. A published report, based upon long-term permanent monitoring plots established by the Forest Inventory and Analysis (FIA) unit in Ogden, Utah in 2002, confirmed the presence and severity of aspen decline symptoms throughout range of aspen forests, from Canada to Mexico. The report recommended the establishment of additional off-plot sites to identify specific aspen damage agents, and to quantify the extent of tree and clone dieback and mortality. In 2006 we began a three-year program to establish monitoring plots in aspen stands in Nevada, Utah, Southern Idaho, Western Wyoming, and Montana to provide additional data on specific damage agents of aspen forests to supplement the established FIA Forest Health Monitoring plot system efforts.

Funding for all three years was received from the USDA Forest Service, Forest Health Monitoring program. Permanent fixed-radius plot level data collected included slope, elevation, GPS location, relative clone stability, and successional status. Large tree (> 5-inches DBH) data taken included: tree species, DBH, percent dieback, tree condition (live, fresh dead, older dead), crown class, and presence and severity of damaging agents. Small trees (≥2" dbh but <5") and seedlings (<2" dbh) were sampled on three nested 1/300th acre sub-plots within each plot. Tree species, number per plot and damage agent(s) and severity were recorded on the nested sub-plots.

The project data for all three years is still being summarized and analyzed. Preliminary data collected from over 5,000 aspen stems on 200-permanent plots indicates the following information about the agents responsible for aspen dieback.

1. Wood borers, were the most frequently observed aspen damage agents; in all three years. *Saperda calcarata, Agrilus liragus,* and *Dicerca spp.* were found along with several unidentified borers.
2. The second most frequently recorded class of aspen damage agents was attributed to fungal stem cankers caused by *Cytospora chrysosperma* and *Encoelia pruinosa,* and other canker diseases.
3. The category of "Defoliating agents" garnered third place all three years as the most frequently recorded damage agent. However, specific causal agent frequency changed over the extent of the large range of aspen during this survey owing to seasonal and site variations.

This rapid assessment of declining aspen stands in the Northern and Intermountain Regions suggests that the identified biotic agents listed above likely contribute to the aspen dieback and mortality; however, other predisposing and inciting factors are involved. Drought, stand succession to conifers, and fire, logging, and grazing histories need to be considered. Eventual synthesis of these factors with weather data, and the damage agent report data, should provide more insight into the aspen decline phenomenon.

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Cytospora Canker Complex on Colorado's Aspen

Jeff Kepley[1], Brent Reeves[2] and Gerry Adams[3]

Cytospora canker is a serious fungal disease affecting aspen in natural, and commercial forests as well as urban sites. In Colorado the causal organism responsible for this canker disease is typically reported as *Cytospora chrysosperma* (Pers.) Fr. However, a thorough understanding of the species of Cytospora attacking aspen in Colorado is lacking. Examinations of cankers on aspen stems in Colorado revealed a morphologically distinct Cytospora-like fungus frequently co-occurs with *C. chrysosperma*. This fungus is a new species and is closely associated with and superficially resembles *C. chrysosperma*. Based on these findings Cytospora canker on aspen in Colorado is a complex of fungi, contradicting what is typically reported in the literature.

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[2] Dr. Brent Reeves, Dept. of Biology, Colorado State University
[3] Dr. Gerry Adams, Michigan State University

Isoenzyme analysis was employed as an initial step to determine if genetic/biochemical differences occur among *C. chrysosperma* and newly discovered non *C. chrysosperma* isolates. Of the twelve enzyme systems initially screened only three, viz., alpha esterase, amylase, and glucose-6-phosphatedehydrogenase, provided good resolution for all isolates. Following cluster analysis two major clades well delineated the two taxa. Phylogenetic analyses of ITS1-5.8S-ITS2 rDNA and EF-1α sequences produced phylogenetic trees in which non-*C. chrysosperma* isolates formed a monophyletic clade (with strong bootstrap support and high posterior probability) within a *Cytospora spp.* phylogeny. Based on these results the non-*C. chrysosperma* isolates from aspen in Colorado are considered a new *Cytospora* species. *Ascostromata* and *conidiomata* (natural specimens) of the new *Cytospora sp.* have conceptacles and conceptacle-like tissues which gives fruit bodies a unique target-like appearance.

Decay of Fire-Killed Western Larch

Marcus B. Jackson[1]

Little is known about changes in fire-killed western larch. A study was undertaken to understand the causes and rates of these changes in four size classes of western larch. Dissected trees were evaluated one, two, three, and five years postfire for char, percent stain and peripheral decay, and depth and number of checks and wood borer holes. Standing trees were evaluated for conk development all five years, including year four (no dissections). Trees were scaled by a certified scaler to determine losses in merchantable volume during the first three years. Decay findings are summarized here, with more comprehensive information about study methods and findings in Jackson, et al. (2010). Peripheral decay, or decay initiated at or near the wood periphery after mortality, was detected by two methods; (1) visual examination of disks removed from stems at eight foot intervals along felled stems and (2) observation of conks on standing trees.

Figure 1. Evaluating disks for char, checks, wood borer holes, stain, and peripheral decay

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Disk observations allowed for quantification of the decay for each tree. Little peripheral decay was detected on disks until three years postfire, with about 10% and 16% of the volume decayed three and five years postfire, respectively. More than 90% of basidiomycete isolations from peripheral decay three years postfire yielded *Fomitopsis pinicola* (Swartz:Fr.) Karst.

Figure 2. Scaling logs in cubic and Scribner rules (Photo by John Schwandt)

No trees contained conks one year postfire and only 0.3% had *Cryptoporus volvatus* (Pk.) Shear conks two years postfire. Conks were found on 18% of the trees three years postfire; 10% with *F. pinicola* conks, 5% with *C. volvatus* conks, and 3% with both *F. pinicola* and *C. volvatus* conks. Four years postfire, conk development increased substantially with 44% of the trees showing fruiting bodies. Thirty-eight percent had *F. pinicola* conks, 3% had *Trichaptum abietinum* (Dickson:Fr.) Ryvarden conks, 2% had *C. volvatus* conks, and 0.5% had *Gleophyllum sepiarium* (Wulfen:Fr.) P. Karst. conks. Little change in conk development was observed between four and five years postfire.

Reference

Jackson, M.B., Bulaon, B.M. and Marsden, M.A. 2010. Wood Changes in Four Size Classes of Fire-Killed Western Larch. Western Journal of Applied Forestry. Accepted May 20, 200

Balsam Woolly Adelgid – an Emerging Architect of High Elevation Forests in the West

Kris Chadwick[1], Lia Spiegel[2] and Connie Mehmel[3]

Balsam woolly adelgid (BWA) is an exotic, aphid-like insect that feeds only on true firs. It feeds directly through the bark on stems and tree branches, causing branch gouting, dieback and tree death. It has a complex life history. While males are known from its native range where it has alternate hosts, female only populations appear to cycle endlessly on firs in the United States. It was first documented west of the Cascades in Oregon in about 1930 and Washington in 1952. It was first found east of the Cascades in 1972 near Walla Walla in southeastern Washington. Since then it has spread throughout most of the subalpine fir in Oregon, Idaho, and southern Washington, causing widespread mortality to mature trees. While it has been studied in firs west of the Cascades, very little is known about host damage and susceptibility in drier, east-side sites. Environmental factors appear to be the prime regulators in the abundance of this insect, with warmer conditions allowing for population increases. Once present at a site, populations appear to wax and wane but never completely vanish. Suspected climatic limitations when this insect was first found west of the Cascades have not been borne out. Further eastward spread into the Rockies appears likely.

We installed long-term monitoring plots in high elevation stands to capture the current range of infestation and damage throughout eastern Oregon and Washington. We hope to revisit sites in 5-10 years.

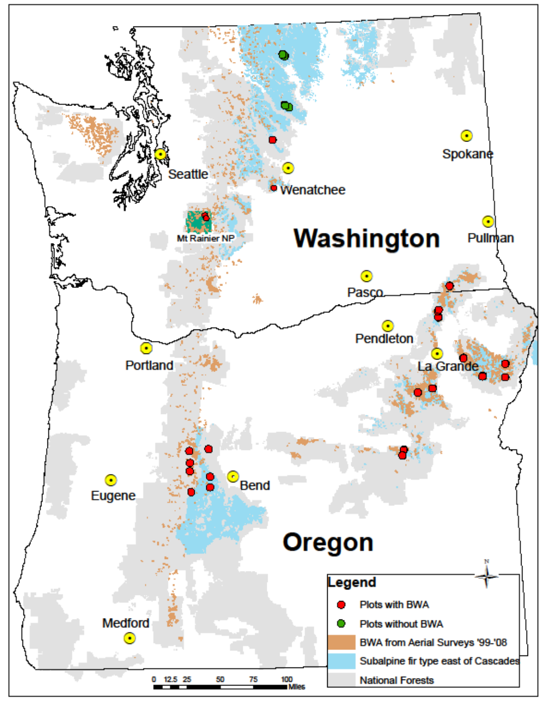

Figure 1. Range of subalpine fir, BWA detected during aerial surveys, and study plots with and without BWA.

Three measures of BWA damage and abundance were developed to characterize the infestation in east-side true firs. BWAR (balsam woolly adelgid rating) captures crown damage in the form of dieback and dead branches. It is an adaptation of the white pineblister rust severity rapid rating system developed by Six and Newcomb (2005) and based on the Hawksworth (1977) dwarf mistletoe rating system. BWAR rates tree crown damage by thirds, with each crown third receiving a rating of 0-4, with 4 indicating no live branches. Gouting severity is a measure of infestation evident on branches. While bole infestation is a measure of insect density evident on the stem of trees. Different trees exhibit different patterns of attack and these measures attempted to capture this variability.

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BWAR and gouting varied together in severity between plots (Figure 2). BWAR and gouting were both very low to absent in Washington. Many other factors appear to be causing subalpine fir mortality in Washington, including Cytospora canker and *Pityokteines minutus*. This twig beetle appears to be acting as a tree killer in these drought-stressed stands.

Adelgids seem to be strongly controlled by host condition and weather. Mortality of subalpine fir was highest in the Blue Mountains of NE Oregon and SW Washington, and also high in one area of Central Oregon. In examining the data for Northeastern Oregon there appears to be a relationship between elevation and subalpine fir mortality (Figure 3). It appears that the mid-elevation subalpine fir suffered the most mortality, however two areas with the same elevation have the highest mortality and nearly the lowest mortality. We suspect that other site factors such as snow cover or humidity play a role in the success of adelgids. Russ Mitchell (Mitchell 2001) found that infestation and damage on the west side of the Cascades is worst in the best sites and the lowest elevations. We hope to combine our data with that from Idaho to try to establish fir susceptibility factors in the more continental climate east of the Cascades.

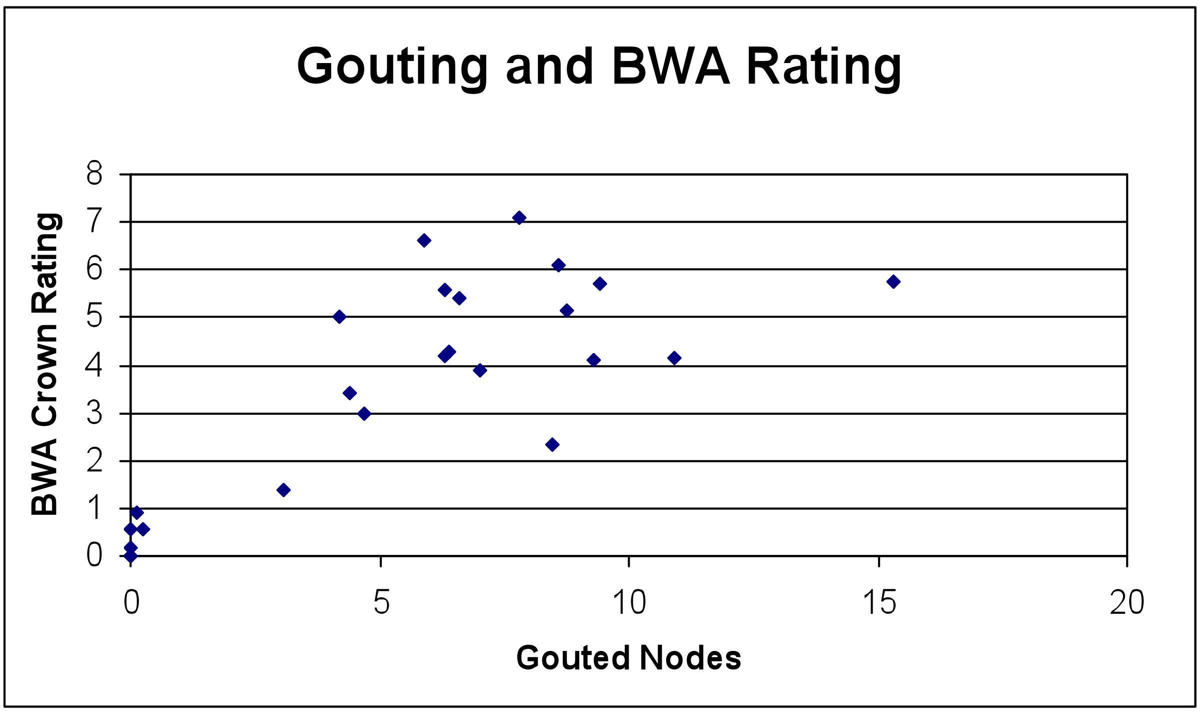

Figure 2. Measures of gouting and crown infestation varied together. These may be good indicators for tracking infestation severity.

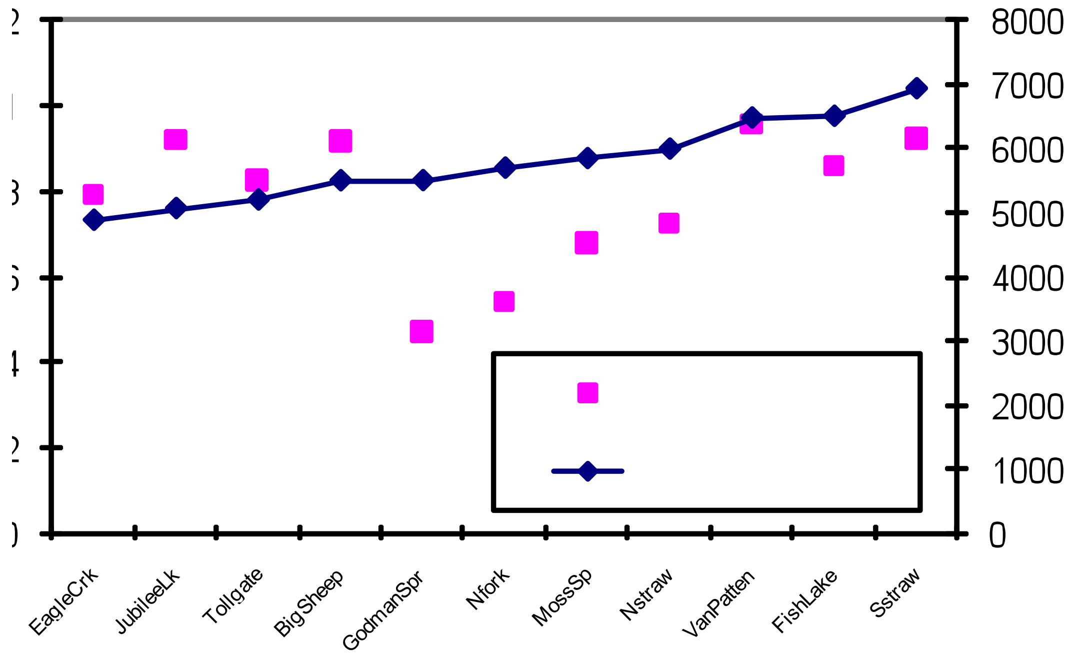

Figure 3. Mid-elevation fir appear to suffer the highest mortality. However, Godman and Big Sheep are at the same elevation and have nearly the highest and lowest mortality, resp.

Kris Chadwick

Subalpine Fir Decline in Southern Idaho

Laura Lazarus[1]

Subalpine fir (*Abies lasiocarpa)* and Engelmann spruce (*Picea engelmannii)* occur together in southern Idaho in a wide zone of elevations between 6,500 and 10,500 feet. The ability of the two species to thrive in lower elevations is predicated on occupying cool moist areas such as stream bottoms or steep northern slopes. Ecologically, subalpine fir is a late successional species (very shade tolerant).

Currently large numbers of all size and age-classes of subalpine fir are dying in southern Idaho. This is not the first time that widespread mortality of this species has been noted:

1950's: mortality attributed to drought-induced *Cytospora sp.* infection;

1960's: widespread mortality attributed to excessive moisture;

1970's: lower elevation firs dying from drought-induced *Fomes annosus* attacks;

1980's: widespread western spruce budworm defoliation across southern Idaho;

1990-1991: two-weeks of record-breaking winter blizzard (dubbed "The Siberian Express") freeze-dried trees, led to increased *Cytospora sp.* infections and top-kill.

2002: balsam wooley adelgid (BWA) found for first time in southern Idaho;

2009: mortality levels high near expanding BWA populations; also high in southeastern Idaho, and attributed to western balsam bark beetle.

The research literature on subalpine fir indicates the species can tolerate a wide range of moisture conditions. It is thought that the total amount of precipitation is not as significant as the effectiveness of the moisture when considered within the context of the firs to the edaphic and topographic influences of the stand. For instance, even if a site has a high evapo-transpiration to precipitation ratio, subalpine fir can tolerate summer droughts if on the right site (i.e. north facing slope, alpine area, or drainage bottom).

Another factor to consider is that fire danger is usually low in the ecological niches that subalpine fir occupies because cool, moist conditions and a short season of growth limit the annual fire danger to the species. Consequently the species can get very old (> 300-years) and large (> 160-feet) with a solid branch canopy extending from the soil up to the top of the tree. It is the infrequent stand-replacing fires that shape natural renewal of firs.

No single organism or weather event can explain subalpine fir decline in southern Idaho. Likely site factors and prior human influences (through past logging, fire control, grazing, etc.) have created an old and unsustainable population of subalpine fir trees.

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Whitebark Pine Restoration Program: History and Progress

John Schwandt[1] and Holly Kearns[2]

Background

The Whitebark Pine Restoration Program had its beginning in 2003 with a special report commissioned by the Forest Health Protection (FHP) Washington Office on managing white pine ecosystems to reduce the impacts of white pine blister rust. Safiya Sammon put together a group of white pine specialists across the country to briefly compile information about the impacts of white pine blister rust on all five-needled pines and outline integrated strategies to protect, sustain, and restore white pines (Samman, et al. 2003). As a result of this effort, a special project was initiated to compile a health assessment of whitebark pine across its range, compile restoration strategies for managers, and describe information needs and challenges to restoration. The results of this special detail were summarized in "Whitebark Pine in Peril; a Case for Restoration" (Schwandt, J.W., 2006). This assessment found that whitebark pine was dramatically declining across much of its range dueto fire, competing vegetation, bark beetle outbreaks, and white pine blister rust. With the exception of blister rust, these problems have historically been the recycling agents for whitebark pine ecosystems.

However, the introduction of white pine blister rust has interrupted the historic successional pathways by changing the way forests regenerate as small trees can be killed rapidly while infections in larger trees may reduce cone crops. White pine blister rust infection levels vary widely across the range of whitebark pine with the highest levels generally found in the Rocky Mountains (Table 1). However, both high and low levels of infection can be found in many places across the range of whitebark pine indicating that local environment may play a large role in rust impacts.

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Table 1. White pine blister rust infection levels in whitebark pine across its range (see Schwandt, 2008 for citation details)

Geographic Region - Reference	Range of Infection	Mean
British Columbia (range-wide) (Campbell & Antos 2000)	0 - 100%	50.0%
British Columbia (range-wide) (Zeglan 2002)	11 - 52.5%	38.0%
Northern Rocky Mountains (U.S., Canada) (Smith et al. 2006)	0-100%	43.6%
Selkirk Mountains, northern Idaho-5 stands (Kegley et al. 2004)	57-81%	70.0%
Colville NF, NE Washington -2 reports (Ward et al. 2006)	23-44%	41.4%
Greater Yellowstone Ecosystem (GYWPMWG 2005)	0-100%	25.0%
Intermountain West (Id, Nv, Wy, Ca) (Smith and Hoffman 2000)	0-100%	35.0%
Blue Mountains, NE Oregon (Ward et al. 2006)	0-100%	64.0%
Coast Range; Olympic Mtns., Wa - 2 reports (Ward et al. 2006)	4-49%	19.0%
Western Cascades; Wa/Or – 6 reports (Ward et al. 2006)	0-100%	32.3%
Eastern Cascades; Wa/Or – 13 reports (Ward et al. 2006)	0-90%	32.3%
Coastal Mountains, southwest Oregon (Goheen et al. 2002)	0 - 100%	52.0 %
California—statewide (Maloney and Dunlap 2006)	0-71%	11.7%

Although blister rust breeding programs are well established for sugar pine and western white pine, breeding for rust resistance in whitebark pine is still in its infancy. Early trials have found that there appears to be a low frequency of rust resistance in whitebark similar to that of western white pine, and efforts are being taken to collect and test seed from apparently resistant trees.

Mountain pine beetle outbreaks in portions of the whitebark pine range have recently increased the urgency to find rust resistant trees before they are killed by bark beetles (Figure 1). These have been summarized in a recent report by Gibson (Gibson, K., et al. 2008)

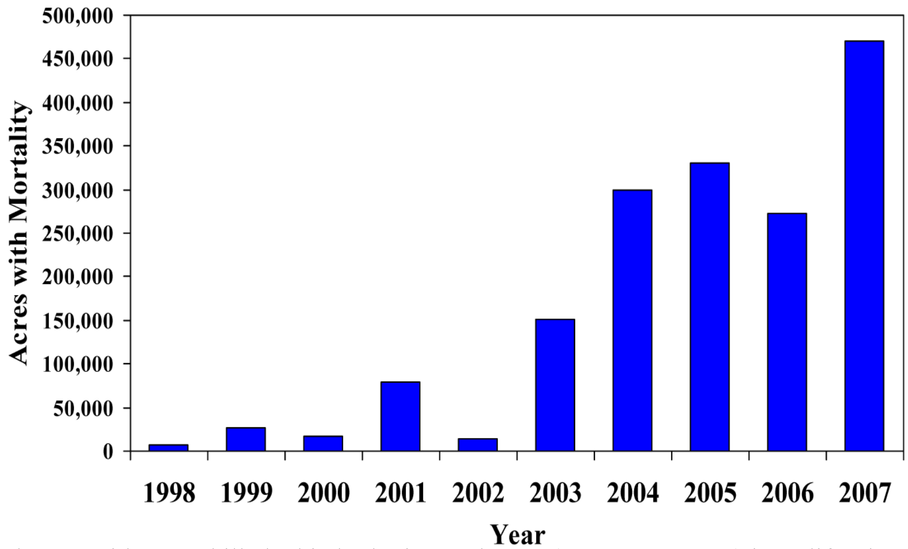

Figure 1. Total acres with MPB-killed whitebark pine each year (1998-2007 ADS) in California, Idaho, Montana, Nevada, Oregon, Washington, and Wyoming

Program Progress

In 2006, the Washington Office of FHP authorized the current whitebark pine restoration program. A multi-agency, multi-disciplinary Technical Committee was established to develop a process to solicit restoration proposals, develop evaluation criteria, and rank proposals. Proposals were placed into six major restoration strategies and evaluated based on scope, objectives, cost efficiency, and technical merit.

- Assessing ecosystem health (surveys and monitoring)
- Harnessing natural resistance (plus tree selection and screening for rust resistance)
- Conserving genetic diversity (operational cone collections)
- Silvicultural treatments to enhance whitebark pine
- Special projects to improve restoration efforts
- Outreach and educational efforts

For the first three years, we developed a solicitation process that requested brief "pre-proposals" that would encourage submissions that could help us gage the level of overall program needs. Pre-proposals were evaluated and a more detailed proposal was requested from the top ranking projects which were then re-evaluated by the technical committee to make final recommendations for funding.

The pre-proposals indicated that there was a multi-million dollar need for restoration projects in whitebark pine. This total did not include over $200,000 in bark beetle suppression projects funded by Forest Health Protection and several hundred thousand more in projects funded outside this program directly by the national forests, BLM, and other agencies.

After the first two years, people quit submitting very expensive proposals, as they realized funding was limited, so even though we received requests for nearly one million dollars in 2009, it probably did not reflect the total restoration needs very well. In 2010, funding distribution was expected to be much earlier so the RFP process was abbreviated to a single proposal that had to be submitted during field season. As a result of this and the lack of large projects, the total requests were less than $700,000.

Table 2 provides a summary of the projects received and funding requests. The number of projects, amount requested, and final projects funded dramatically increased the first three years. Even though the initial seed money from FHP was only $200,000 the first 2 years and has dropped to $150,000, FHP support has remained high and additional FHP funding was added each year which helped expand the program well beyond the initial amounts.

The widespread support for this program has been impressive as the level of matching funds has always been greater than the FHP amounts requested, and sunk costs (expenses invested in prior years) were even greater.

In 2009, the Whitebark Pine Ecosystem Foundation contributed $30,000 to the 2009 program which helped fund planting and sowing projects on the Lolo, Flathead, Idaho Panhandle, and Clearwater National Forests. As a tribute to the widespread success of these efforts, the Whitebark Pine Restoration Program received the Region-1 Regional Forester's Natural Resources Stewardship Award in 2009.

Table 2. Whitebark Pine Restoration Program History

	2007	**2008**	**2009**	**2010**
# Proposals Received	56	62	60	38
Total $ Requested	$1,000,000	$2,200,000	$960,000	$670,000
# Projects Funded	24	26	43	9 +?
$ Forest Health Funds	$267,400	$398,900	$385,000	$150,000+?
$ Match	$291,700	$433,900	$550,000	$615,000?
Total	**$559,100**	**$832,800**	**$935,000**	**?**

Matching funds have come from a broad and diverse group of state and federal agencies, universities, ski areas, National Parks, and private foundations (Table 3). We have also had an opportunity to work directly with a few whitebark pine restoration projects. One of these is a two-year Evaluation Monitoring project document what is left after whitebark pine stands have been subjected to intense mountain pine beetle outbreaks. We have surveyed over 40 stands during the past two years and have found many stands have lost 70-90% of the mature whitebark pine to mountain pine beetle in the past few years. Severe losses of mature trees may have significant impacts on natural regeneration as the Clark's nutcrackers which are the primary dispersal agent may not be attracted to stands with so few cone bearing trees and trees with nature resistance to white pine blister rust may be killed (Schwandt et al. 2008)

We are also installing a series of direct seeding trials to develop methods for planting whitebark pine in isolated areas where planting seedlings is not possible. Two trials in Oregon have been promising and four more trials are planned for installation in the fall of 2009.

Since whitebark pine restoration is thought to be closely tied to fires in much of its range, a series of monitoring plots were established in different burn intensities following a prescribed burn in northern Idaho in 2005. These plots will be monitored on 5-year intervals to document levels of regeneration and survival.

In existing stands, competing vegetation may be responsible for reducing regeneration success; so another study was established with the IPNF to establish different thinning intensities around small whitebark. Survival, growth rates, and blister rust infection levels will be monitored over time to compare impacts of two different opening sizes (7' vs 12' radius) around existing trees of three height classes (1-5 ft, 5-10ft and >10').

Coordinating this program has been a real challenge, but we have thoroughly enjoyed the experience of working with such a group of enthusiastic partners that are dedicated to enhancing restoration of whitebark pine in the face of losses from bark beetles, competition, fire, and especially white pine blister rust. We still have a long way to go, but we hope that these restoration efforts will continue to grow so that whitebark pine will continue to play an important role in high elevation ecosystems.

Table 3. Cooperators and Partners for Whitebark Pine restoration Program 2007-2009

Non-Federal Funding Sources	**Parks and Recreation Areas**
Private and Non-Profit Groups	Akamina-Kishenina Provincial Park (BC)
Arbor Day Foundation	BC Parks and Protected Areas (Canada)
Global Forest Science	Crater Lake National Park
Montana Natural History Center	Glacier National Park
Montana Department of Natural Resources	Grant Teton National Park
Mt. Batchelor Ski and Summer Resort	Mount Rainier National Park
Mule Deer Foundation	North Cascades National Park
New World Mine Restoration	Sawtooth National Recreation Area
Remote Sensing Applications Center	Waterton Lakes National Park (Canada)
RLK & Co Timberline Lodge and Resort	Yellowstone National Park
Seattle City Light	
Whitebark Pine Ecosystem Foundation	**Native American Tribes**
	Blackfoot Tribe
Universities and Colleges	Confederated Tribes of Warm Springs (Or)
Colorado State University	Flathead Indian Reservation (Mt)
Grove City College (Bend, Or)	Wind River Indian Reservation (Wy)
Montana State University	
Oregon State University	**Over 30 National Forests in Regions 1,2,4,5,6**
University of Colorado	**Other Federal Cooperators**
University of Idaho	Bureau of Land Management (BLM)
University of Montana	Dorena Genetic Resource Center (Or)
Utah State University	Greater Yellowstone Coordinating Committee
State Agencies	Pacific Northwest Research Station (PNW)
Idaho Fish and Game Department	RMRS Fire Research Laboratory
Montana Department of Natural Resources	USFS Coeur d'Alene Nursery
Washington Dept of Fish and Wildlife	US Geologic Survey

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Phytophthora pinifolia on *Pinus radiata* in Chile

Philip G. Cannon[1]

Identification of a new pathogen

This presentation is based largely on a synthesis of information provided by Jeff Stone (tree foliage pathologist at Oregon State University), Roberto Ahumada (lead forest pathologist for Arauco Forestal, Chile) and Francisco Flores (also with Arauco) all of whom have been heavily involved with studying a new disease that has caused heavy killing of the foliage of *Pinus radiata* in some plantations of this species in the central coast of Chile. Additional information was extracted from the literature on this pathogen.

Extensive tree mortality was first noticed in 2004 in a six-year-old *P. radiata* stand on the Arauco coast of Chile. The cause of the problem was not immediately identified, but foliar pathogens were suspected based on the fact that initiation of the problem often began with a narrow chlorotic band in an otherwise perfectly green needle.

Both Jeff Stone and Mike Wingfield went to see the impacted plantation on repeat occasions but no foliar pathogens could be observed or isolated from their first visits. On a third visit, when both were present, Wingfield managed to get several isolations of a pythiaceous species using a selective media for Oomycetes. Morphological considerations of the cultures and molecular analysis of the DNA showed that it was a Phytophthora but both the morphological features and the DNA were different from any other Phytopthora species. For this reason it was given the name *Phytophthora pinifolia*. On a phylogenetic tree its closest relatives are *P. gonapodyides* and *P. megasperma* (Duran *et al*, 2008).

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Confirmation that these early isolates could be pathogenic proved challenging. Repeated inoculation attempts all turned out negative. Finally, Paul Reeser went to Chile and developed a technique that is highly successful for getting the pathogen to attack the foliage; basically it involved placing the recently inoculated needles in a test tube filled with water.

The impact of the disease

This *Pinus radiata* stand first affected in 2004 was in an especially wet part of the Peninsula of Concepcion and occupied 70 hectares (Duran *et al*, 2008). Many trees were killed outright, but there were also a very high proportion of trees in this stand that were only intermediately impacted. The most commonly observed symptoms were that impacted trees had a large portion of their needles turn red, particularly needles on the lower side of the lower branches.

By 2005, the extent of plantations affected by this disease was 6,000 ha and by 2006 it was at 60,000 ha. This demonstrated that this disease, under favorable conditions, can spread very quickly. However, the amount of newly impacted plantations was less than 1,000 ha in 2007 and 2008. The dramatic turnaround in the rate of spread has been attributed mainly to climate; 2004, 2005 and 2006 were very wet years; 2007 and 2008 were dry.

Figure 1. Initial symptoms of *Phytophthora pinifolia* attack on *Pinus radiata* in Chile.

In order to keep track of the extent and distribution of this problem, Francisco Flores has developed a technique for keeping track of live leaf area index using remote sensing. Heavily diseased trees appear as tree with less than normal foliage. He can also layer on other geographic information onto these images. This capability has helped show that stands that are in areas which would receive large amounts of rainfall (windward sites in close proximity to the Pacific) and areas that would have relatively low evaporation rates (south-facing slopes) are especially vulnerable to develop the disease.

At present, the general observation is that the pathogen rarely kills radiata pine that is greater than the sapling stage in size. Never the less it can kill trees smaller than this and it can cause a canker just below terminal buds in trees larger than this.

Figure 2. Typical symptoms of *Pinus radiata* in Chile when it is being attacked by *Phytophthora pinifolia.*

Dealing with the Disease

In recent years, Arauco Florestal and other Chilean Forest companies have become a lot more confident that they can deal with this disease. One of their chief tools is to identify those sites that would be most likely to have the climatic conditions conducive to foment this disease (during wet years) and simply plant these sites with a different species, such as *Eucalyptus nitens* or *E. globulus*.

The sporangial stage of this pathogen is the most common form of natural inoculum that is involved when an epidemic with this pathogen is underway, but these spores die off quickly when conditions are unfavorable for even a few hours. However, this Phytophthora, like most other Phytopthora's does produce a resting oidium stage, and these oidia could survive in the needle litter and provide a source of new inoculum for years into the future. Fortunately, according to Stone, it takes almost six weeks of continuous rainfall before the oidia in this litter could start producing sporangium again. The only time this is likely to happen is during extreme Nino years.

Containing the problem in Chile

The success of the *Pinus radiata* industry in Chile is predicated on the ability of that country to be able to export plantation-grown logs. A study was done to see if whole logs or lumber cut from logs was capable of carrying viable inoculum. Hundreds of attempted isolations from logs and boards all turned up negative. A second study was also conducted to see if logs could be inoculated in any way with inoculum in anyway and have the pathogen survive. Reisolations following this procedure also came up negative for the pathogen (Ahumada, 2009). This evidence suggests that there is low risk that logs of lumber exported from Chile could effectively transmit the pathogen to a different country.

Figure 3. The most severely impacted stand of *Pinus radiata* in Chile.

Preparations for the possible arrival of *P. pinifolia in* the US

Although the risks are extremely low that *P. pinifolia* would be brought in by lumber from Chile, this pathogen still might find its way to the US via a number of different means. If this were to happen, it would be of interest to see how other US tree species might be impacted by this species. Towards determining the answer to this question, Jeff Stone has arranged to establish some Sentinel Plantings of twenty coniferous tree species native in the US in an area in Chile which is especially conducive to the development of the disease.

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Cuernos del Paine from Lake Pehoe´ (Wilipedia Commons)

Determining if There are Lines of Guava Rust (*Puccinia psidii*) That Could Seriously Impact Ohia (*Metrosideros polymorpha*), in Hawaii

Philip G. Cannon[1], Acelino Couto Alfenas[2], Rodrigo Garca Neves, Mee-Sook Kim, Tobin Peever and Ned Klopfenstein

Introduction

The rust, *Puccinia psidii*, was first found on the leaves, stems and fruit of guava in Brazil in 1894 (Winter, 1984). As a result, it was first called guava rust. It has subsequently been identified in other countries of the western hemisphere including Paraguay in 1884, Uruguay in 1989, Puerto Rico in 1913, Colombia in 1913, Cuba in 1926, Jamaica in 1936, Florida in 1979, Mexico in 1981, El Salvador in 1987 (Simpson *et al*, 2006). It has also been found in California in 2004. This progression of finds suggests that this rust fungus has been moving to new locations, especially in a northerly and westerly direction from its point of origin.

In 2005, *P. psidii* showed up in Oahu, Hawai'i (Killgore and Heu, 2005; Uchida *et al*, 2006). Within two years after arriving on Oahu, this rust was well-distributed on every other Hawaiian Island, as well. One hypothesis is that the Hawaiian strain came from California. However, this rust is very scarce in California (CFPC, 2008). It will probably take molecular genetic analyses of appropriate samples to determine the actual route this rust took to get to Hawaii.

Worldwide, *Puccinia psidii* has already shown a capacity to attack plants in 20 genera in the family Myrtaceae (Simpson *et al*, 2006). Eucalyptus is one genus in the family Myrtaceae that is of great interest internationally. In one test in Brazil, with 39 species of *Eucalyptus* and *Corymbia*, 37 of the species tested were found to be susceptible to this fungus (Alfenas and Zauza, unpbl. data, reported in Glen *et al*, 2007).

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To date, the strain of the rust that has made it to Hawaii has not been found on any eucalypts, but is has killed a very high proportion of one already-endangered native Myrtaceae (*Eugenia koolauensis*). An exotic-invasive bush species, *Syzyzium jambos* (the Indian Rose Apple) has also been very heavily impacted. Previously, *S. jambos* had colonized many tens of thousands of hectares of Hawaii mainly in the form of one to five hectare clumps of very tall bushes. The rust only affects the current year's flushes of foliage of the rose apple, but it can annihilate this foliage completely and after about three years of loosing new foliage, the rose apple simply dies.

The Impact on Ohia

The strain of *P. psidii* that has made it to Hawaii can also attack ohia (*Metrosideros polymorpha*) and this is undoubtedly the item of greatest concern in Hawaii. Ohia trees comprise about 85% of all native forests in Hawaii. If this rust could kill extensive amounts of Hawaii's ohia forests, the impact would be hugely deleterious to the biodiversity, watersheds, natural beauty and many other attributes that these forests provide.

So far, the impact of the rust has not been very heavy on existing ohia trees found across Hawaii, even where there are heavily-infected clumps of rose apple right nearby. In arboretum settings it is apparent that some ohia varieties are much more susceptible to this fungus than are others. But even with the most vulnerable varieties, only the most juvenile leaves become infected.

Perhaps the most troubling demonstration of the possible impact of this fungus is in nurseries where ohia are being raised and where there happens to be nearby, heavily-infected, rose apple clumps that are providing a heavy spore load. Under these circumstances a majority of ohia seedlings show sign of infection and some die. Fortunately, in the natural forests, although there are some ohia seedlings that have been infected by this rust, the proportion of affected seedlings found to date has been very low.

From a purely pragmatic point of view, therefore, the impact of this particular rust strain might be considered a nuisance in Hawaii, but a tolerable one.

Figure 1. *Puccinia psidii* pustules on the leaves of a heavily attacked Rose apple (*Shyzyzium jambos*) stem (Photo courtesy of J.B. Friday).

The possibility of more aggressive strain of *P. psidii* coming to Hawaii

Although P. *psidii* is already widespread in Hawaii, the genetic marker analyses that have been performed on about 60 different samples of this fungus, collected from all over Hawai'i, suggests that all of the sources have the same genetic composition.

For this reason, the Hawaiian authorities are very concerned that a more aggressive strain of *Puccinia psidii* will find its way to Hawaii and cause considerably more damage to local myrtaceae, and especially the ohia trees.

Towards preventing this from happening, the Hawaiian authorities set up an interim measure to prevent the entrance of any myrtaceous plant or plant parts from coming into the state. This interim law was in effect from March 2006 until March of 2007 and was then automatically voided. The law has been replaced with an inspection routine. Currently all shipments of myrtaceous species coming into Hawaii are examined by Agricultural Inspectors at the ports of entry. If no sign of **P. psidii** can be found on the inspected plants, then they are allowed to pass on to their intended destinations.

There are a few limitations in the logic of using either a total blockage approach of Myrtaceae into Hawaii or of using just an inspection at entry approach. One of the major shortcomings in both is that it is unknown whether there might actually be a more aggressive strain of guava rust.

The Test

Towards resolving this question of whether there might be strains of *Puccinia psidii* that could be much more pathogenic on ohia, an appropriate test is being initiated. It involves the following steps:
About 300 viable seeds were collected from each of 24 distinct families of ohia from many diverse locations in Hawaii; these seed have been shipped to Vicosa, Brazil where they are being grown as seedlings to about one year of age.

Approximately 300 single-pustule isolations have been made of *Puccinia psidii* in Brazil and neighboring countries and these have been (or are being) bulked up to produce sufficient quantities of each strain so that the DNA of each strain can be extracted and analyzed for their respective genetic markers.

Once all of these genetic analyses are completed, the phylogeny of this rust will be established and this information, coupled with any information on the apparent aggressiveness of a strain, will be used to select 8 distinct strains for use in pathogenicity tests (note: one of the strains that will be used will be one that matches up with the strain already in Hawai'i; this will take some special attention but will not be covered exhaustively here). The pathogenicity test will consist of an 8 x 24 factorial test with six blocks. In each block of this test, 8 strains of this rust will be inoculated onto 15 seedlings of each of the 24 different ohia families.

The degree to which the rust has developed on all 11,520 ohia plants in this test will be evaluated at three weeks and six weeks following inoculation and the appropriate statistical tests will be performed.

The data and the conclusions of this study, whatever they might be, will be presented to the authorities in Hawaii and should provide an accurate estimation of whether there could be a more aggressive strain of guava rust for the ohia tree.

Based on the above, it is hoped and expected that the authorities in Hawaii will have a much more accurate concept of the risk that an influx of additional strains of *P. psidii* might present to their islands. Armed with this information they will be able to make better-informed decisions regarding regulations to place on Myrtaceous species coming into Hawaii.

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Philip G. Cannon

Pests- Pacific Rim & Beyond-Identifying New Potential Pathogens

Will Littke[1]

Exotic Diseases: The panel objective was to look at developing pest conditions outside of the continental US and to identify new and potentially damaging pathogens. Secondly, to elaborate on specific pest threats and information sources concerning their biology, host specificity, and damage potential.

Why is this happening now? Certainly, the current onslaught of new pest introductions is being driven by developments in global foreign trade involving a wide array of commodities: Other issues such as; (a) harvest of tropical forests for food and products brings agricultural species in closer proximity to native tree species; (b) export of wood dunnage, logs and other wood products provides an introduction conduit fueled by internal demand being met with exotic forest species; (c) increased movement of seed, seedlings and germplasm (Photo 1); and (d) through incidental introduction during movement of non-forest crop and agricultural species.

Many traditional forest silviculture methods have given way to faster growing exotic plantations in developing countries. History has taught us that pests will follow along this pathway of establishment.

Who will introduce these pests? US and Canadian consumers will as a consequence of their demand for global commerce trade. For example, in the early 1990's, the concern was placed squarely on imported forestry products, however APHIS and USDA did the needed pest risks assessments. Later we learned the "backdoor" was left often with regard to untreated dunnage packaging wood.

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What kind of pests? Where will they come from? We can begin to assess this risk by accessing several databases on exotic pests; (1) pest risk assessments by APHIS for specific import commodities; (2) lists of intercepted pests at US ports; (3) compiled lists from the literature; and (4) published genetic studies on pathogen groups (Tables 1-3).

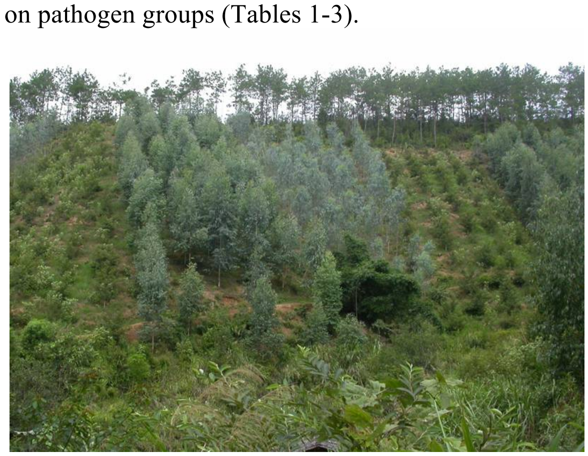

Photo 1. Eucalyptus and other non-native species trial in southern China.

What can we anticipate will happen? It is difficult to predict the timing of the next exotic pathogen introduction, but as to what group it might belong to may be another question. The literature from Asia suggests there is a wide diversity of leaf and shoot pathogens that belong several important pathogen genera including; *Botrysphaeria, Kirramyces, Mycosphaerella, Lasiodiplodia, Cryptosporiopsis, Colletogloeopsis, and Quambalaria.* The common denominator that makes these pathogens distinctive are their broad host specificity, rapid spread rate, and demonstrated ability to cause economic damage to crop trees. Meanwhile, strange new pathogens with serious human health consequences such as *Cryptococcus gattii* (*Filobasidiella neoformans* var. *neoformans*) have been introduced to British Columbia.

Table 1. Examples of information sources concerning biology, host specificity, and distribution of forest related exotic pests and pathogens.

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Table 2. Synopsis of Fungi Listed as Regulated Plant Pests by USDA APHIS: fungi affecting tree species.

Pathogen	Disease	Distribution	Potential Hosts
Aecidum mori	rust	Asia	Broussonetria and Morus
*Allontophomopsis pseudotsuage**	canker	US,Europe, NZ	Pinaceae and Sequoia
Chrysomyxa abietis (autoecious rust) *Chrysomyxa himalensis (macrocyclic)* *Chyrsomyxa rhododendri (macrocyclic)*	rust	Europe, Asia Asia	Picea spp. Rhododendron (T) Picea (A) Rhododendron (T) Picea (A but not in US)
Cronartium flaccidium (macrocyclic)	rust	Europe, Asia	Several herbaceous (T) Pinus (A)
Guignardia pyricola	canker	Asia	Pyrus, Malus, Rosaceae
Lachnellula willkommii	canker	Asia, introduced US	Larix,Pseudolarix
Xylobus (Stereum) hiugensis	white rot	Asia (Japan)	Quercus

Table 3. Kliejunas, J.T. et. al. 2003 pathogens with broad host specificity identified potentially associated with various imported wood products.

Pathogen	Disease	Hosts	Materials
Armillaria *A. fumosa, A. hinnulea, A. luteobubalina, A. pallidula*	root rot	Eucalyptus and broad host range	bark, sapwood, heartwood
Botryosphaeria ribis	canker	Eucalyptus, Corymbia, Cercis, cornus, Liquiambar, Malus, Pinus, Plantanus, Tilia, Ulmus and 100 other	foliage, bark sapwood
Calonectria reteaudii	canker	Eucalyptus and related species	seedlings foliage
Cytospora eucalypticola *Cytospora eucalyptina*	canker	Eucalyptus, Acer, Alnus, Liqidamber, Quercus, Malus and many other species	bark, sapwood
Mycosphaerella spp. (11)	foliage and canker	Eucalyptus and related species	bark, sapwood
Phellinus spp (5)	root and bole decay	Broad host range	Sapwood, heartwood
Phytophthora cinnamomi	root disease	Broad host range	bark, sapwood
Seirium *S. Eucalypti* *S. papillatum*	foliage	Eucalyptus and related species	Foliage, bark, sapwood

Synopsis: The literature suggests that many new potential pathogens to North American forests are "***lying in wait***" throughout the world. The surge in forest development throughout Asia and elsewhere is providing one conduit for pathogen expansion from native species to much broader host distributions. These new exotic forests may provide "sentinel" areas to intercept and study new pathogen groups prior to their eventual introduction into North American ecosystems.

Some general panel conclusions are offered:

- Biosecurity of forests, agricultural lands, and the environment is a rapidly developing interest area, since as global trade increases so does the potential for exotic pest introductions.

- A strong emphasis on pro-active elimination of pathways of introductions coupled with a quick strong eradication effort will pay a much bigger dividend, in the long-run, than simple reliance on reactive pest management controls.

- A need for a move to a rapid molecular based detection and identification system to replace our reliance on slow classical culture and morphological approaches.

- What experience in managing past invasive species issues provides a model for our future actions, should they become necessary. What's been a success story?

- Funding for a building a strong defensive biosecurity program in the U.S. is lagging behind other countries.

- Building a strong expertise in identification and control of exotic pests is being made more difficult as the workforce ages and retires and university shift curriculums away from pathology and entomology.

Will Littke

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A National View…Early Detection Rapid Response (EDRR), FHM Evaluation Monitoring, and EXFOR and Risk Analysis

Bruce Moltzan[1]

FHP goals: Forest Health Protection's FHP mission is to protect and improve the health of America's rural, wildland, and urban forests. We are part of the State and Private Forestry Deputy Area of the U.S. Department of Agriculture, US Forest Service. We have over 250 specialists in the areas of forest entomology, forest pathology, invasive plants, pesticide use, survey and monitoring, suppression and control, technology development, and other forest health-related services. Our staffs are located in Forest Service National Head-quarters, all Regional Offices, the Northeastern Area Office, the International Institute of Tropical Forestry, the Institute of Pacific Islands Forestry, and over 25 field offices. FHP's has five National goals that address prevention, early detection & rapid response, control and management, Rehabilitation and restoration, and Technology Transfer.

FHM: Under FHP umbrella is the Forest Health Monitoring (FHM) national program designed to determine the status, changes, and trends in indicators of forest condition on an annual basis. The FHM program uses data from ground plots and surveys, aerial surveys, and other biotic and abiotic data sources to develop analytical approaches to address forest health issues that affect the sustainability of forest ecosystems. In addition FHM provides competitive Evaluation Monitoring Funding to support on-going detection surveys and protocol development. One such effort is the National Sudden Oak Death detection survey conducted annually in 320 unique watersheds and 22 states that are set up in wooded environs specifically around previously infected SOD positive nurseries. Results gathered from this survey continue to detect *P. ramorum* in states like MS, AL, and FL.

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EDRR: Early Detection and Rapid Response (EDRR) is a critical component of the US Forest Service invasive species program. We have collected, processed, and identified thousands of samples from funnel traps baited with ethanol (to capture ambrosia beetles), Ipslure (to capture scolytine engravers), and pinene-ethanol (to capture turpentine and other secondary beetles) and placed in urban forests and near port facilities and wood-handling facilities. We have recovered *Xylosandrus compactus*, *Xylosandrus crassiusculus*, *Xylosandrus germanus*, *Gnathotrichus materiarius*, *Monarthrum fasciatum*, and *M. mali* - beetles which are known to occur within the USA. In addition, we continue to check samples for any new or recent introductions. Current efforts focus on the following target species: *Hylurgops palliatus*, *Hylurgus ligniperda*, *Tomicus piniperda*, *Scolytus schevyrewi*, *Ips sexdentatus*, *Ips typographus*, *Orthotomicus erosus*, *Pityogenes chalcographus*, *Xyleborus glabratus*, *Xyleborus similis*, and *Trypodendron domesticum*.

This program is a targeted detection and response effort that supports efforts to detect high-risk exotic species early enough to pursue control and/or eradication actions. Future goals include additional training of field personnel and students, development of new trapping, screening, and identification methods, and cooperation with the Forest Health Technology Enterprise Team and Threat Assessment Centers on risk-rating for species and ecosystems.

FHTET: The Forest Health Technology Enterprise Team (FHTET) is sponsored by FHP to develop and deliver services to field personnel in public and private organizations in support of the Forest Service's land ethic, to "*promote the sustainability of ecosystems by ensuring their health, diversity, and productivity*." FHTET has two components; support the Forest Service in meeting its legal mandate for the protecting forest health and provide technology services on a cost-reimbursable basis. Examples of services include; EXFOR database, International Tree Failure Database, Risk maps, Aerial survey and sketch mapping, and utilizing MODUS to edge closer to real time evaluation of changes within the forest on a landscape level.

2008 Investments:

FHP 2008 Invasives expenditures in 2008 totaled on the order of 25 million to support efforts against Gypsy Moth (13.5M), Invasive Plants (4.4M), Hemlock Wooly Adelgid (2.4M), Emerald Ash Borer (1.4M), Sudden Oak Death (1.3M), White Pine Blister Rust (871K), Sirex Woodwasp (181K), and Asian Longhorned Beetle (138K). While this represents a broad array of invasive pests, FHP continues to be on the look out for the next pest.

EWS: One model to address new introductions is to develop a strategic framework or Early Warning System (EWS) based on the national effort against catastrophic environmental threats to forest health. This framework can illustrate to forest managers, specialists, and practitioners the necessary components of early detection and rapid response, and facilitate the practical consideration and inclusion of important elements during planning and management activities. It can be used to identify gaps, weaknesses, and unnecessary redundancies in the national system of detection and response, focusing research efforts to address gaps and weaknesses, and enabling significant improvements in information, processes, coordination, networking, and organizational structures. It also can highlight opportunities for increased cooperation and collaboration and serve as an aid for prioritizing proposed projects, management emphases, or available resources.

Suggestions:

To be effective in getting action taken on a new pest we must realize that things move slowly as most of these new organisms are new to science. Basic biological information on how to detect and control will take time. It is suggested that forest health specialists collaborate broadly, construct a 'good story' or plan to deal with the pest, and communicate widely to get the message out. By forming broad partnerships early on in the establishment of invasives will at least allow many paddles to help move the regulatory effort up stream. As the pieces of the puzzle fall into place constantly update the plan with the big picture of integrated management in mind. Recognize that in the words of Upton Sinclair, "It is difficult to get someone to understand something when their job depends on not understanding it." Remember it's not that folks in Washington don't want to understand, they need the story to be put in a workable context quickly in order to provide dollars.

The need for applied pathologists, taxonomist, and forest health specialist is going to be great as the threat from invasives continues. Efforts to encourage forest pathology in land grant universities must be maintained to meet this growing demand.

Bruce Moltzan & Phil Cannon

White Pine Blister Rust in the Interior Mountain West

Kelly Burns[1], Jim Blodgett, Dave Conklin, Brian Geils, Jim Hoffman, Marcus Jackson, William Jacobi, Holly Kearns and Anna Schoettle

Introduction

White pine blister rust is an exotic, invasive disease of white, stone, and foxtail pines (also referred to as white pines or five-needle pines) in the genus *Pinus* and subgenus *Strobus* (Price and others 1998). *Cronartium ribicola*, the fungus that causes WPBR, requires an alternate host - currants and gooseberries in the genus *Ribe*s and species of *Pedicularis* and *Castilleja* (McDonald and others 2006, Zambino and others 2007) - to complete its life cycle. White pine blister rust was discovered in western North America in 1921. It is thought that the disease was accidentally introduced on infected eastern white pine (*Pinus strobus*) nursery stock shipped to Vancouver, BC from Europe in the early 1900s but the specific details are unclear. Since then, the disease has spread throughout the distributions of most western white pines. Although all of the North American white pine species are susceptible to white pine blister rust (Bingham 1972, Hoff and others 1980), it was once thought that the remote, dry habitats occupied by the noncommercial, high elevation white pines would not support rust establishment. Unfortunately, white pine blister rust can now be found in many of these areas.

Over the past decade, members of the Central Rockies White Pine Health Working Group have collaborated to monitor the spread and establishment of white pine blister rust in the high elevation white pines of the Interior Mountain West - the broad region that encompasses USDA Forest ServiceIntermountain (Utah, Nevada, and southern Idaho), Southwestern (Arizona and New Mexico), and Rocky Mountain Regions (Colorado, Wyoming, South Dakota, and Nebraska), and the eastern portion of the Northern Region (central Montana and North Dakota) (see Fig. 2). The infection front lies within this region and a large portion of its susceptible white pine population has not been challenged by the disease. This publication provides some background on the high elevation hosts and synthesizes current information onthe distribution and impacts of white pine blister rust in these more recently infested areas. A summary of current and ongoing efforts for managing the disease is also provided.

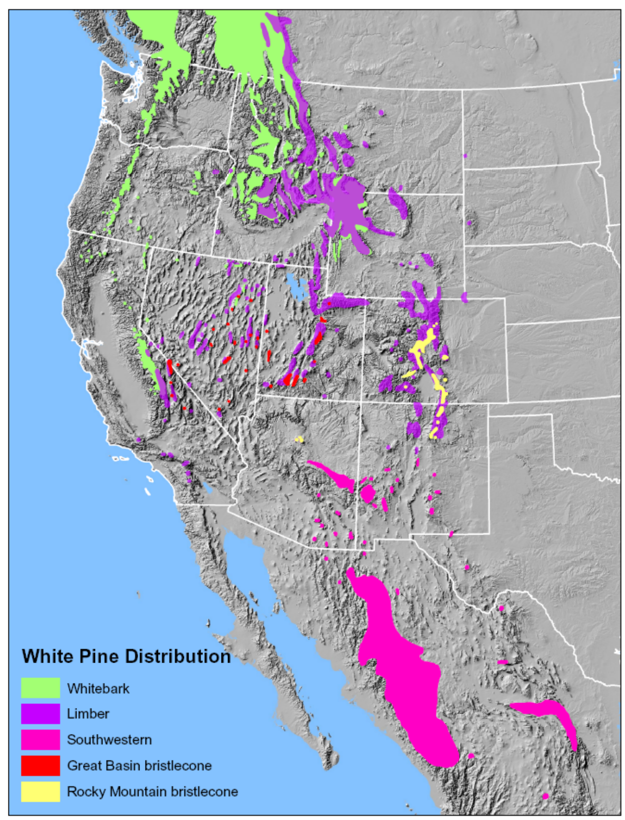

Figure 1. Distribution of high elevation white pine species that grow in the Interior Mountain West.

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Hosts

White pines are well distributed within the forested areas of the Interior Mountain West (Fig. 1). Pine hosts in this region include whitebark pine (*Pinus albicaulis*), limber pine (*P. flexilis*), Rocky Mountain bristlecone pine (*P. aristata*), Great Basin bristlecone pine (*P. longaeva*), and southwestern white pine (*P. strobiformis*). These species grow at high elevations and are especially important because of their unique ecological and cultural characteristics. They provide cover and regulate snow and runoff on steep, rocky sites where little else can grow; their seeds are an important food source for corvid bird species, small rodents, grizzly bears, and other animals; and they are some of our oldest and largest pines.

Whitebark pine is widely distributed in two broad sections within western North America – from the Coast Range of British Columbia into the Cascade and Sierra Nevada Mountains and from the Canadian Rockies to the Middle Rocky Mountains of Wyoming. Scattered outlying populations occur within and around these sections. The species is a major component of high elevation, timberline forests of Idaho, Montana, and western Wyoming. The seeds of whitebark pine are large and wingless and enclosed in a cone that does not open upon ripening. Clark's nutcrackers extract the seeds and serve as the primary dispersal mechanism. A number of scatter-hoarding birds and small mammals contribute slightly to seed dispersal. Many species of wildlife, such as red squirrels and grizzly bear, rely on whitebark pine seeds as an important part of their diet. Blister rust-infected whitebark pines were first observed in the Coast Range of British Columbia in 1926 and in the Northern Rocky Mountains n 1938 (Childs and others 1938). Mortality caused by the disease is greatest in whitebark pine stands of the Northern Rockies where infection levels are variable but frequently greater than 70 percent (Kendall and Keane 2001, Schwandt 2006). The incidence in the more recently infected Greater Yellowstone Ecosystem is estimated to be 25 percent (Greater Yellowstone Whitebark Pine Monitoring Working Group 2006).

Limber pine is widely distributed in the west from Alberta and southeastern British Colombia to New Mexico, and southeastern California with isolated populations in North Dakota, South Dakota, Nebraska, eastern Oregon, central Arizona, and southwestern California (Burns and Honkala 1990). Limber pine has a very wide elevational distribution as well, ranging from 2,850 feet in North Dakota to 12,500 feet in Colorado (Burns and Honkala 1990). In the Northern Rocky Mountains, limber pine generally occurs at lower elevations. In the Southern Rocky Mountains, limber pine has a very wide elevational range, from the grassland-forest ecotone at 5,250 ft to the subalpine-alpine ecotone at 11,482 feet and everywhere in between (Schoettle and Rochelle 2000). Limber pine seeds are wingless (or nearly wingless) and rely on the Clark's nutcracker for dispersal. In contrast to whitebark pine, limber pine cones open upon seed maturity. Its seeds also provide food for squirrels and may therefore affect prey populations of the Canada lynx. Limber pine tends to be one of the first species established after fire on dry sites and can facilitate the establishment of other species that eventually replace it on the more mesic sites. This species can tolerate very harsh, exposed sites and can reach ages over 1,000 years. Infected limber pines were first observed in central Montana in 1944 (Riley 1944), southern Idaho in the 1940s (Krebill 1964), and central Wyoming in 1959 (USDA Forest Service 1959, Brown 1967).

Southwestern white pine is distributed in the mountains of western Texas, New Mexico, Arizona, and southwestern Colorado, but most of its distribution is in Mexico. Limber pine and southwestern white pine hybridize where their distributions overlap, so distribution and range information is somewhat unclear. The species generally occurs as a minor component of mixed-conifer and spruce-fir stands, and higher elevation ponderosa pine stands, but may become dominant on high elevation, cool sites. In New Mexico and Arizona there are more than 30 geographically isolated populations. Like limber and whitebark pine, southwestern white pine seeds are essentially wingless, but the seed dispersal mechanisms are not fully understood. White pine blister rust was discovered on southwestern white pine for the first time in 1990 in southern New Mexico (Hawksworth 1990). Since then, the disease has been observed in the northern and western parts of the state (Conklin and others 2009) and more recently in Arizona (M.L. Fairweather personal communication). The disease has not been reported on southwestern white pine in Colorado, Texas, or Mexico to date.

Great Basin bristlecone pine occurs in eastern California, Nevada, and Utah. It grows high in the mountains from 6,760 feet in Nevada up to 12,000 feet in California. The species has a remarkable ability for surviving under adverse conditions and is slow-growing and very long-lived. For example, one tree in Great Basin National Park in eastern Nevada is estimated to be 4,950 years old – the oldest living single organism in the world. Even though the distribution of Great Basin bristlecone pine overlaps with other susceptible white pine species no infected trees have been observed to date. It is the only five-needle pine species in the United States that remains uninfected.

Rocky Mountain (RM) bristlecone pine's distribution is almost entirely within the state of Colorado with a small portion extending into northern New Mexico, and an outlying population in central Arizona. This species was distinguished from Great Basin bristlecone pine in 1970 (Bailey 1970). RM bristlecone grows from 9,000 to 12,040 feet in elevation and can be very long-lived, reaching life spans of over 2,600 years old. It is primarily a subalpine species but it can also grow in and amongst ponderosa pine (*P. ponderosa*) and piñon pine (*P. edulis*). Like limber pine, it forms long-lived stands on dry exposed slopes and ridges and regenerates after fire though colonization is slow (Coop and Schoettle 2009). This species has winged seeds that are wind-dispersed but are also dispersed by nutcrackers and other corvids. White pine blister rust was first observed on Rocky Mountain bristlecone pine in 2003 near Mosca Pass in the Great Sand Dunes National Park and Preserve, Alamosa County, Colorado (Blodgett and Sullivan 2004, Burns 2006).

Impacts of White Pine Blister Rust in the Interior Mountain West

White pine blister rust impacts all phases of the regeneration cycle. The disease affects trees of all ages and sizes and could potentially eliminate white pines from certain ecosystems and landscapes. Young trees are especially susceptible and cone potential is greatly impacted on infected large trees when most or all of the cone-bearing branches are killed. Although the impacts of the disease are similar in the high elevation and low elevation white pine species, there are some important differences. The white pine species of the Interior Mountain West grow high in the mountains with broad valleys separating populations - this limits gene flow and changes the dynamics of disease spread.

It appears likely that aeciospores can disperse very long distances in upper level air currents to eventually infect pines (Frank and others 2008). Opportunities for such long distance spread are rare since climatic conditions must be favorable at both the source location and the target location at the appropriate time (Frank and others 2008).

Conditions suitable for intensification are also infrequent, but thought to be associated with large-scale weather systems that create conditions favorable for infection throughout the crown, as opposed to the diurnal events that occur near the ground in the low elevation species (Jacobi and others 2002). Because of this, it is not unusual for severe decline to result without a stem infection when numerous branch infections occur throughout the crown. Additionally, susceptible *Ribes* species and white pines occur together throughout the Interior Mountain West so there is no reason to assume the remaining ecosystems will escape infection.

A mountain pine beetle epidemic is occurring throughout the west and unfortunately mature white pines are particularly suitable hosts. The combined effects of mountain pine beetle and white pine blister rust have caused extensive mortality in whitebark pine in the Northern and Intermountain Regions. In the Rocky Mountain Region, mountain pine beetles are devastating some limber pine and Rocky Mountain bristlecone pine stands. Mountain pine beetles threaten ancient trees and sites with confirmed resistance to blister rust. Bark beetles kill mature cone-bearing trees reducing regeneration potential. Forest recovery is further impaired by white pine blister rust, which rapidly kills small trees.

Current Distribution of White Pine Blister Rust

The distribution of white pine blister rust was summarized for the Interior Mountain West in 2003 (Geils and others 2003) but since has expanded to several new locations. A map of the current known distribution of white pine blister rust is displayed in Figure 2. The most notable new outbreak areas are in southern Idaho, eastern Arizona, western and northern New Mexico, and Colorado. New information on the distribution of the disease is reported below by sub-regions.

Colorado and Wyoming: In Wyoming, white pine blister rust was first discovered in Yellowstone National Park on *Ribes* in 1944 (USDA Forest Service 1950) and then on whitebark pine in 1950 (USDA Forest Service 1951). The disease front has slowly progressed east and south since then. Infected pines were reported on the Shoshone National Forest in 1966 (Brown 1967), the Bighorn National Forest in 1959 (USDA Forest Service 1959, Brown 1967), and Laramie Peak, Medicine Bow National Forest, in 1969 (Brown 1978). An examination of limber pine on Pole Mountain in the early 1980s revealed very light infection levels (B.W. Geils, unpublished data). The most comprehensive survey of central and south-central Wyoming was recently completed (Kearns and Jacobi 2007) and the disease was reported in the Medicine Bow and Sierra Madre (Kearns and Burns 2005) Mountains of southern Wyoming for the first time. Incidence of WPBR is greatest in northern Wyoming and in areas where the disease has been present for decades. The incidence of WPBR is currently low in the Medicine Bow and Sierra Madre Mountains.

White pine blister rust was discovered on limber pine on the Roosevelt National Forest in northern Colorado just below the Wyoming border in 1998 (Johnson and Jacobi 2000). These new infections were likely the result of southward spread from Wyoming (Brown 1978). Other parts of Colorado had not been surveyed extensively until 2002 when field crews discovered infected trees on the San Isabel National Forest in the Sangre de Cristo and Wet Mountains of southern Colorado. Infections in southern Colorado were found primarily on limber pine, but infected Rocky Mountain bristlecone pines were also observed for the first time in their native range in the Great Sand Dunes National Park and Preserve (Blodgett and Sullivan 2004). The incidence in southern Colorado is generally low but isolated infection centers have been discovered in other parts of Colorado since then. The disease was discovered 4.5 miles southeast of Estes Park in 2005 (R. Beam and J. Klutsch, unpublished data); 4 miles north of Nederland in 2006 (J.T. Hoffman, unpublished data); and on Pikes Peak in 2009 (K.S. Burns, unpublished data).

Southwestern Mountains (Arizona and New Mexico): White pine blister rust was discovered on southwestern white pine in the Sacramento Mountains of southern New Mexico on the Lincoln National Forest in 1990 (Hawksworth 1990). Subsequent surveys identified the disease in several other locations farther north in New Mexico, including the White Mountains in 1991, Capitan Mountains in 1994, and Gallinas Peak in 1999 (Conklin 2004, Geils and others 1999). More recently, blister rust was discovered in western New Mexico on the Gila National Forest in 2005 and in northern New Mexico in the Jemez Mountains in 2006 and Zuni Mountains in 2007 (Conklin and others 2009).

In the past it has been assumed that conditions in much of Arizona were unfavorable for rust establishment but infected southwestern white pines were observed on the Fort Apache Indian Reservation and the Apache-Sitgreaves National Forest in 2009 (M.L. Fairweather, personnel communication). More in-depth surveys will be needed to determine how extensive the outbreak is in Arizona.

Great Basin and surrounding areas (Nevada, Utah, southern Idaho): Although some populations remain uninfected, white pine blister rust has been present on National Forests in Idaho since the 1960s (Brown and Graham 1969, Krebill 1964). A small population of limber pine in Craters of the Moon National Monument and Preserve in southern Idaho was discovered to be infected in 2006. Infected limber pines were identified at Emigration Pass in Bear Lake County, southeastern Idaho in 2002 (B. Geils, unpublished data). In Nevada, blister rust was discovered in whitebark pine and western white pine (*P. monticola*) in the western part of the state in 1997 (Smith and others 2000) and was confirmed in whitebark pine in northeastern Nevada in 2002 (Vogler and Charlet 2004). Blister rust has not been reported in Great Basin bristlecone pine or limber pine in Nevada or Utah. Infected *Ribes inerme* leaves were observed in Carbon County, Utah, in 2005 (B.W. Geils and D.R. Vogler, unpublished data), but the disease has never been reported on pine hosts in that state.

Great Plains and surrounding areas (North Dakota, South Dakota, Nebraska, and Central Montana): Blister rust infection was reported on limber pines on the eastern slope of the Rocky Mountains in Montana for the first time in 1944 (Riley 1944). Very little information is available on the status of white pines in central Montana but a survey conducted in 2007 found an average incidence of 50 percent in 16 limber pine plots (Burns and others, in review). White pine blister rust was discovered on a single planted limber pine in an urban area in central North Dakota in 1992 (Draper and Walla 1993). The disease was not detected in subsequent white pine surveys of native white pine stands in 1992 and 2007 (Burns and others, in review). White pine blister rust was detected in a small outlying limber pine population in the Black Hills National Forest of South Dakota (Lundquist and others 1992) in 1992. The disease has not been reported in the any of the small outlying limber pine populations located where the Nebraska, Wyoming, and Colorado borders meet.

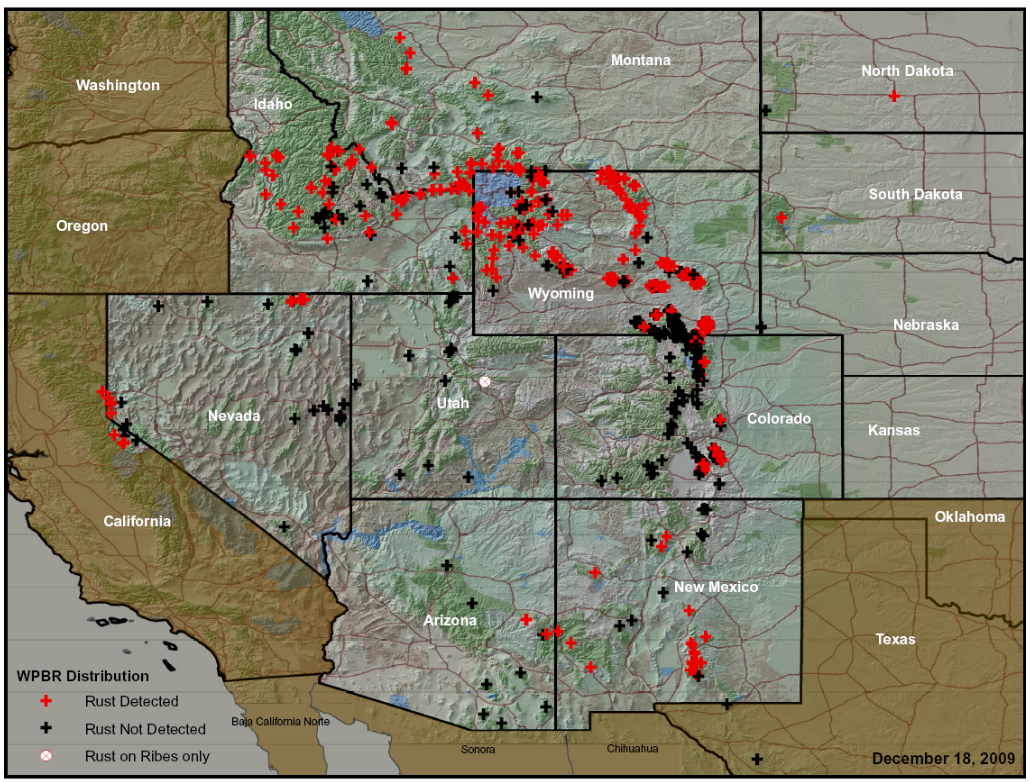

Figure 2. Distribution of white pine blister rust in the Interior Mountain West.

Current and Ongoing Efforts for Managing the Disease

Despite efforts to control white pine blister rust, the disease continues to spread and intensify. Control strategies have been developed for the commercial species but these strategies have not been tested on the high elevation species and they may not be applicable in the Interior Mountain West. We are taking a proactive approach where possible (Schoettle and Sniezko 2007) and are involved in a variety of projects aimed at improving our ability to manage the disease in the high elevation species of the Interior Mountain West. Examples of current projects are summarized in the following section.

Resistance Screening: Efforts to locate putatively resistant trees (and random trees in uninfected areas) and screen progeny for blister rust resistance are underway for limber pine, Rocky Mountain bristlecone pine, southwestern white pine, and whitebark pine (Kinloch and Dupper 2002, Mahalovich and others 2006, Schoettle and Sneizko 2007, Schoettle and others 2009, Sneizko and others 2007, Vogler and others 2006). Examples of specific disease resistance projects include tests for complete resistance in limber pine families and populations (Schoettle, Sniezko, Burns, Connor) and southwestern white pine (Vogler, Sniezko and Conklin) as well as tests for partial resistance in limber pine and RM bristlecone pine families (Schoettle, Sniezko, Pineda-Bovin, and Burns).

Southern Rockies White Pine Conservation Project: The mountain pine beetle epidemic threatens ancient trees and trees with confirmed rust resistance. Rocky Mountain Research Station, Rocky Mountain Region (R2) and Northern Region (R1) Forest Health Management, several R2 National Forests, Colorado State University, Rocky Mountain National Park, Great Sand Dunes National Park and Preserve, and Dorena Genetic Resource Center have teamed up in a race against the beetles (Schoettle and others 2008). Limber and Rocky Mountain bristlecone pine populations are being protected from mountain pine beetles (using insecticides or verbenone) and seed collections, began in 2003, are ongoing for conservation, restoration, rust resistance screening, and other research applications.

Long-term Monitoring: Long-term monitoring plots have been established throughout the Interior Mountain West to evaluate the impacts of white pine blister rust over time (Burns and others 2009, in press; Conklin 2004).

Meteorology Studies: Researchers are evaluating micro-scale meteorological conditions in pine ecosystems in Colorado and Wyoming and whether they can predict the impact of white pine blister rust (Goodrich, Jacobi, Kearns, and Geils). Longterm meteorological measurements are also ongoing to support studies of climate change and to compliment other genetic and ecological studies (Schoettle).

Planting and Regeneration Studies: The objective of this study is to develop and refine guidelines for planting limber pine seedlings and to survey regeneration to determine current stand characteristics and natural regeneration rates (Casper, Jacobi, Schoettle, and Burns).

Pruning Trials: The feasibility of pruning cankers, excising cankers, and/or lifting crowns for protecting and prolonging the life of high-value trees is being evaluated in limber and Rocky Mountain bristlecone pine in two recreation areas – the Great Sand Dunes National Park and Preserve, southern Colorado and Vedauwoo Campground, and southeastern Wyoming (Crump, Jacobi, Burns, Howell).

Verbenone Trials: The efficacy of using verbenone to protect limber pine from mountain pine beetle is being tested in Colorado. Preliminary results indicate that trees treated with verbenone are less likely to be attacked but success varies by site and a large portion of trees are still attacked so the treatment will probably not be effective over the course of an outbreak (Costello, unpublished data).

Management Guides: New publications are available that summarize options for the management of white pine blister rust for the Southwestern Region (Conklin and others 2009) and the Rocky Mountain Region (Burns and others 2008).

High Elevation White Pine Website: An educational website was created to provide a clearinghouse of information on the high elevation white pines (Schoettle and Laskowski 2006).


Kelly Burns

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White Pine Blister Rust on New Telial Hosts (*Castilleja* And *Pedicularis*) in Whitebark Pine Ecosystems at Mt. Rainier and Crater Lake National Parks

Robin L. Mulvey[1]

Background

Whitebark pine (*Pinus albicaulis*) is considered a critical component of high-elevation ecosystems in the western United States. White pine blister rust (WPBR), caused by the non-native, heteroecious rust fungus *Cronartium ribicola*, is one of several factors contributing to whitebark pine mortality throughout its range. It has long been known that strains of *C. ribicola* present in North America are able to complete the telial stage of their lifecycle on currants and gooseberries in the genus *Ribes*. However, in 2006 McDonald et al. confirmed *C. ribicola* infection on species within the genera *Castilleja* and *Pedicularis* (family *Orobanchaceae*) in the northern Rocky Mountains.

Research Objectives and Project Summary (Unpublished)

The objectives of this research were: i) to determine whether species of *Castilleja* and *Pedicularis* play a role in the WPBR disease cycle in whitebark pine ecosystems of the Cascade Range and ii) to track spore stage progression on aecial and telial hosts to determine if there is sufficient time for *C. ribicola* to complete its lifecycle within high-elevation whitebark pine ecosystems.

Field observations during the 2008 field season detected naturally-occurring *C. ribicola* infection on *Pedicularis racemosa* at Mt. Rainier NP and *Castilleja applegatei* at Crater Lake NP. Field inoculations of *P. racemosa* at Mt. Rainier NP and *P. groenlandica* at Crater Lake NP using aeciospores from locally-diseased whitebark pine resulted in successful *C. ribicola* infection. *C. ribicola* infection was confirmed using extraction, PCR and genetic sequencing of the ITS region. Genetic sequencing is necessary to differentiate *C. ribicola* from related *Cronartium* species for which *Castilleja* and *Pedicularis* are also known to serve as hosts.

Field observations continued during the 2009 field season, and field sites were expanded to include whitebark pine ecosystems at Mt. Rainier, Mt. Adams, Mt. Hood, Mt. Bachelor, Mt. Tumelo and Crater Lake. Infection was detected on *P. racemosa*, *C. arachnoidea*, *C. applegatei*, *C. miniata* and *C. parviflora*. Infection was not detected on *Castilleja* and *Pedicularis* at all sites, and infection was observed on *P. racemosa* more frequently than other species within the genera *Castilleja* and *Pedicularis*. Field inoculations during the 2009 field season resulted in successful infection on *P. racemosa*, *P. bracteosa* and *C. arachnoidea*. These are preliminary results and specimens have not yet been sequenced.

Four species of *Castilleja* that are associated with whitebark pine at Crater Lake and Mt. Rainier NPs were cultivated and experimentally inoculated in a growth chamber at Oregon State University during April (108 plants) and May 2009 (180 plants). The aeciospores used to inoculate plants were collected from diseased western white pine (*Pinus monticola*) at Dorena Genetic Resource Center in March 2009. All four species (*C. miniata*, *C. applegatei*, *C. parviflora* and *C. arachnoidea*) demonstrated susceptibility, with an average infection incidence of 65% and infection incidence by species ranging from 30 to 100%. Telia were sometimes observed emerging from upper and lower leaf surfaces of

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Castilleja. Many fewer urediniospores were observed on *Castilleja* species compared with *Ribes nigrum*, which served as the experimental positive control. This apparent reduction in urediniospore production on *Castilleja* may have important epidemiological implications and warrants further investigation. Continued field observations will contribute to the assessment of the relative "importance" of these hosts to the WPBR disease cycle in whitebark pine ecosystems.

Robin L. Mulvey

Special Papers

"Site, Plot, and Individual Stem Volume Variation of Douglas-fir Associated with Non-lethal Infections by Armillaria Root Disease in Southern British Columbia."
Mike Cruickshank

"Overview of Douglas-fir—*Phellinus sulphurascens* Pathosystem Research."
Rona Sturrock

"Proposed Nomenclatural Changes in *Arceuthobium*: Published and Forthcoming."
Bob Mathiason

'Susceptibility and Sporulation Potential of *Phytophthora ramorum* on Some Common Plants in Washington Forests."
Marianne Elliott & Gary Shastagner

Yield Reduction of Douglas-Fir Infected by Armillaria Root Disease in the Southern Interior of British Columbia

Mike Cruickshank[1]

Introduction

Epidemiology of *Armillaria ostoyae* (Romagnesi) Herink in naturally regenerated stands of Douglas-fir in the Interior Cedar Hemlock (ICH) is not well understood. Work by Cruickshank (unpublished results) in fire origin, 80- to100-year-old seral stands dominated by Douglas-fir suggests that mortality occurs throughout a rotation, increasing in frequency after age 80. Following harvest of similar sites, evidence of colonization by *A. ostoyae* was found in 60-90% of stumps (Morrison et al. 2000, 2001, Woods 1994). Disease epidemiology may be altered in planted stands because the site has been changed by leaving *A. ostoyae*-infected stumps, by planting, and by altering species mixtures; hence the timing and magnitude of impacts could differ from those in natural stands. In the southern interior of BC the impact of *A. ostoyae* on growth of 80- to 100-year-old Douglas-fir stands has been estimated (Bloomberg and Morrison 1989), but impacts were not scaled up to stand level. In southern interior BC Douglas-fir plantations no information exists on the magnitude of the disease impacts in individual trees or in stands.

The current study is an initial investigation into the effect of non-lethal Armillaria root disease on volume yield of Douglas-fir in seven plantations. Roots were completely excavated for all study trees and infection dates were determined for every root lesion on selected trees for 1148 trees on seven sites. The impact on yield was determined for individual trees and for stands and the variation was determined at the site, plot, and individual levels.

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Methods

Seven, 20- to 34-year-old Douglas-fir plantations in the Interior Cedar-Hemlock biogeoclimatic zone (ICH) in southern BC were identified for sampling. For each site, 23 to 27 10-m radius plots (0.03 ha) were randomly distributed throughout the site on either side of the main access road, except where travel would not permit and the plots had to be moved locally. All trees in the plots were pulled out of the soil in late fall using a 20-ton Link Belt excavator with a clamshell bucket attachment to minimize the breakage of roots, stems and branches. Lesions caused by *A. ostoyae* were identified by mycelial fans in the bark or cambium (of the lesions) or as mycelial fan impressions in the old bark. For each tree, the proportion of diseased primary roots (>15 mm arising from the root collar) was recorded for each tree. Also for each tree, height from the soil line to the apex and diameter at 1.3 m (DBH) was measured. A non-spatial competition index was calculated for each sampled tree in plots using the sum of the basal area of trees that are larger (BAL) than the target tree. In the plantations, Douglas-fir trees in each plot were identified for full stem analysis (median 5 to 8 per plot). Stem disks were taken at 0, 0.3, 1.3 and every 2 m, including annual height increments, in order to calculate volume change over time. The year of infection for each lesion on the stem analysis trees was determined by traumatic resin canal presence proximal to the lesion (Cruickshank et al. 2006).

Mixed model regression models were fitted using SAS Proc Mixed (Ver. 9.1.3) for tree volume at 5 year observation intervals starting at age 15. Models were identified prior to analysis that included competition (BAL), the tree volume at age 10, the proportion of diseased primary roots and the length of time the tree had been infected. The proportion of diseased roots and the length of time the tree was infected also varied at each observational period, while the other variables were time invariant. Random effects included the site, plot and accumulated time since each tree had been first infected. Models used a spatial power covariance matrix for repeated measures where observational periods were tracked by tree age.

Results

The model fixed effects represent the population averages when the other fixed and random effects are considered. Tree volume between age 10 and the observational period in question, the natural log of volume yield difference (the response), changed according to an inverse function of time, and accounted for significant variation mainly due to growth ($p<0.0001$). The tree volume at age 10 was the most important fixed effect ($p<0.0001$) accounting for the size difference between trees before infection occurs in the stand or sampled trees. Neighbour tree competition reduced the yield ($p<0.0001$) by a power function (1.5). The number of years that the tree had been infected accumulates at each observational period after it first became infected. Stem volume was significantly reduced ($p<0.0001$) according to a power function (0.5) of the time since the tree had first been infected. Yield reduction occurred rapidly after the first infection but then slowed with time, but none of the trees were able to recover to yields predicted by healthy trees growing under similar conditions. The proportion of infected primary roots is a second measure of disease intensity in the root system that often, but not always increasing with time. The root lesions can range from a necrotic patch on one side of a root (most common) to part or the entire root being girdled by the fungus. An increase in disease intensity at any time period had a significant negative linear effect on volume growth ($p=0.0022$) of the tree.

Variation in yield at the site, plot and individual tree hierarchies was greatest at the site intercept level ($\sigma^2=0.82$, $p=0.04$), and variation in site growth over time (slope) was lower ($\sigma^2=0.02$, $p=0.04$). Plot intercepts had lower yield variation than the site intercept ($\sigma^2=0.20$, $p<0.0001$) and variation associated with plot was less than site slope over time ($\sigma^2=0.004$, $p<0.0001$). The plots tended to behave more similarly within sites; however, there were notable significant differences ($p<0.05$) in plot yield within each site. Coefficients for site intercepts and slopes and plot intercepts and slopes were negatively correlated (-0.13 and -0.03 respectively); more specifically, high initial yield at age 15 (intercept) tended to be associated with slowing yield over time (slope). At the individual tree level, random variation in the number of years since the first infection explained further significant variation in addition to the fixed effect for this term ($\sigma^2=0.005$, $p<0.0001$). There were 40 trees from all sites and many plots with significant Best Linear Unbiased Predictors (BLUPs, $p\leq0.05$) that were growing better or worse than the average related to how long they had been diseased.

For a 32-year-old tree of average sized and competition index and with its entire root system infected at age 11, the model predicts a reduction in volume of about 41 dm^3 per tree (33%) after 20 years of disease. An average tree with all its roots infected at age 11 and a tree with 10% of it roots infected at age 11 and no further infections was only 3% greater yield reduction for the greater intensity infection. Relative to a disease-free tree the 5-year annual average reduction tended to be highest between tree age 20 and 30 at 13-17 %. Losses per hectare were calculated based on the number of infected trees in the plots at any one time and the average loss per tree. These ranged from about 5-20 m^3/ha by age 30 depending on the stand. The number of diseased trees/ha at age 20 was positively correlated to the average tree volume at the same age at those sites ($R^2=0.92$).

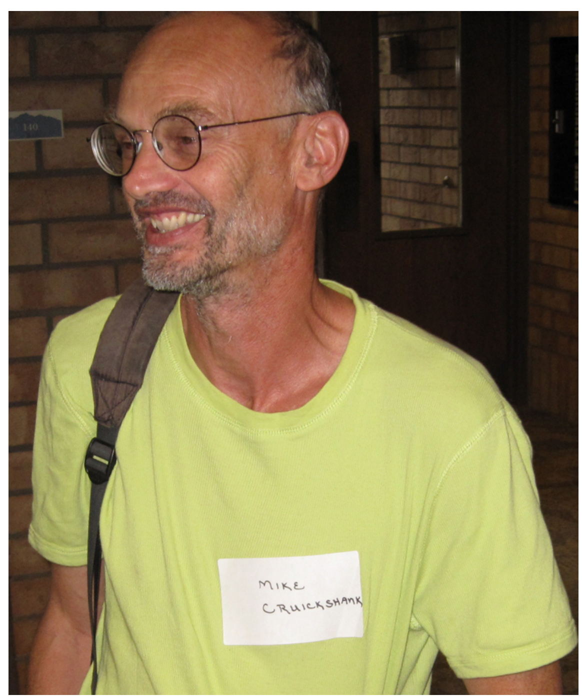
Discussion

For a 5-year period the actual and proportionate volume reductions were highest in the later time periods. Average annual percent volume increment reduction over 5 or 10 years in Douglas-fir with Phellinus root disease was approximately the same as in this study (Thies 1983), and was similar to reduction for Annosus root disease in spruce in stands of similar age (Bendz -Hellgren and Stenlid 1997). The proportionate reductions in this study showed no signs of slowing yet. Studies in undisturbed 100-year-old Douglas-fir in BC suggest that growth reduction in single stems can be greater than 50% after 50 years of infection (Bloomberg and Morrison 1989); however, the total and periodic yield reductions reported here are larger. Non-lethal yield reduction at the site level is rarely calculated but is needed for estimation of disease impacts for economic analyses. In radiata pine in New Zealand, non-lethal volume reduction at the site level was estimated at 5.5 to 11 m^3/ha (Mackenzie 1987), but the range for juvenile sites in this study was about twice as much by age 30 and continuing to accumulate. The number of diseased trees over time was the largest factor affecting yield reduction and may account for differences in volume reduction between the two studies since the pine density in New Zealand was described as wide tree spacing in stands used for grazing.

Random variation in the way the individual trees respond to disease was significant. The effect does appear to be similar to host tolerance which is the ability of a plant to sustain the effects of disease without serious yield loss. Tolerance is often detected by measuring yield in plants with varying levels of pest damage, such as was done in this study, but is usually done with genetically related individuals. Although we had no idea about the level of inoculum the trees were exposed to, we assume that the level of inoculum would be correlated to the percentage of diseased roots accounted for in the model. If host tolerance to disease actually does exist, then breeding stock with this trait may be used to reduce non-lethal yield reduction, but more work is needed to determine if this occurs and how it might relate to host resistance. Alternatively, removing stumps does reduce root disease in this ecosystem but also adds an additional cost. Planting mixed species may add little cost but at lower level of disease control.

This study seems to indicate that keeping conifer growth rates low in the initial years reduces the incidence of disease over time lowering yield reduction. The juvenile stand with the lowest yield reduction also had higher visual levels of competing brush and slow initial growth. Some competing vegetation in the early years would provide part of the site free of conifer roots for a time when some stump inoculum could degrade; in essence, a type of crop rotation. Planting and then high juvenile growth rate probably increases the disease incidence sooner as this study suggests. Unfortunately, larger trees are more valuable suggesting that the interaction of disease, planting density, and site index also needs to be studied. Further, because disease appears to limit site potential, only one infected root is needed for growth reduction, and neighboring trees cannot take advantage of the slower growth or death of neighbors (Cruickshank et al. 2009), yield reduction could be substantial.

The work described here represents one component of risk associated with impact of *A. ostoyae* in Douglas-fir. The second risk impact component needed would be mortality. Together with incidence and a relationship between incidence and yield reduction and mortality, an ecological and economic risk assessment model could be competed for this disease. Only *A. ostoyae* impacts in Douglas-fir are reported here, but most woody species can be infected by this fungus. There are more than 30 species of Armillaria that cover the globe so that the risk to site productivity by stand management alone could be a considerable but is poorly recognized.



Mike Cruickshank

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Susceptibility and Sporulation Potential of *Phytophthora ramorum* on Some Common Plants in Washington Forests

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Abstract

Eight evergreen broadleaved plant species common in western Washington forests were tested for susceptibility and sporulation potential of *Phytophthora ramorum*, the causal agent of Sudden Oak Death. Four native and four invasive plants were selected. A range of susceptibility, from 95% to 0% infection frequency, was observed on foliage. None of the plants produced as many sporangia as California bay laurel, the host responsible for spreading the disease in California forests, but many of them produced similar numbers of chlamydospores.

Introduction

Phytophthora ramorum (Oomycota), the cause of Sudden Oak Death (SOD), is an introduced pathogen that has caused significant damage to forests in coastal California during the past nine years. Spread of the pathogen into new locations is facilitated primarily by the movement of infected nursery stock. Diseased nursery stock has been detected in Washington State since 2003. In recent years *P. ramorum* has moved out of nurseries into waterways, but has not yet become established in the landscape.

The severity of SOD is determined by the host, and there are more than 100 known hosts for *P. ramorum.* Most hosts display only minor symptoms consisting of foliar lesions and sometimes branch dieback. Other hosts develop cankers on the stem which are often fatal; these hosts include species of oak (*Quercus agrifolia, Q. cerris, Q. chrysolepis, Q. falcata, Q. kelloggii*, and *Q. parvula* var. *shrevei*), beech (*Fagus sylvatica*), and tanoak (*Lithocarpus densiflorus*). If there is sufficient inoculum present, *P. ramorum* can kill shrubs and seedlings of other host species. Western Washington is considered a high risk area for SOD, primarily because of a suitable climate for the pathogen and abundance of known hosts (Fowler et al. 2006). While there are no bole canker hosts in Washington forests, many understory shrubs are foliar hosts, including Pacific rhododendron (*Rhododendron macrophyllum*), salal (*Gaultheria shallon*), and Oregon grape (*Mahonia nervosa*).

The objectives of this study were to evaluate the susceptibility of some common native and introduced plants found in western Washington forests to *P. ramorum*, and to assess the sporulation potential of *P. ramorum* on these plants.

Methods

Four native and four non-native broadleaf evergreen shrub species were selected based on their abundance in WA forests and riparian areas (Table 1). Some of these plants are known hosts for *P. ramorum* and others are untested.

Table 1. Plant species used in the study.

Family	Name	Common Name
Natives		
Ericaceae	*Gaultheria shallon*	Salal
Ericaceae	*Arbutus menziesii*	Pacific madrone (juvenile foliage)
Ericaceae	*Rhododendron macrophyllum*	Pacific rhododendron
Berberidaceae	*Mahonia nervosa*	Dwarf Oregon grape
Non-natives		
Rosaceae	*Rubus discolor*	Himalayan blackberry
Lauraceae	*Umbellularia californica*	California bay laurel
Rosaceae	*Prunus laurocerasus*	English Laurel
Araliaceae	*Hedera helix*	English ivy

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Susceptibility to infection by *P. ramorum*

Foliage from five plants of each species was collected and pooled for the experiments. Individual leaves were either placed whole, or they were cut to fit into 9 cm Petri plates with moistened Whatman #1 filter paper discs. Two leaf pieces were positioned in each plate so that both the adaxial and abaxial surfaces were represented. Three treatments were applied to each plant species: wounded with water (control), wounded with inoculum, and unwounded with inoculum. The *P. ramorum* isolate used in all experiments was originally taken from Rhododendron x 'Unique' from an Oregon nursery provided by N. Osterbauer, ODA. This isolate belongs to the NA1 clonal lineage and is A2 mating type. Zoospore inoculum was prepared from four-week-old cultures grown on V8A. Inoculum concentration was adjusted to approximately 10^6 zoospores/ml. A 10µl drop of inoculum or water was placed on each leaf piece and an insect pin was used to wound the tissue through the drop, in each of the wounded treatments. There were five replicates per treatment, representing a total of 20 leaf segments per plant species. The experiment was repeated one time.

Leaves were incubated in the dark for ten days, and lesions were photographed at five and ten day intervals. Lesion area was measured using APS ASSESS v. 2.0. Infection frequency was determined by comparing lesions formed on inoculum treated leaves with lesions on the wounded water-control leaves.

All inoculated leaves were cultured on *Phytophthora* selective media (CARP) to determine inoculum survival and asymptomatic infection. After incubation inoculation sites were swabbed with a sterile cotton swab and the cotton plated on CARP medium. Inoculation sites on each leaf were then excised, surface sterilized, and plated on CARP. Colonies of *P. ramorum* were counted after three days. If a leaf had no visible symptoms but a colony was present on CARP, it was considered to be an asymptomatic infection.

Sporulation of *P. ramorum*

Ten 6 mm leaf disks were placed in a 6 cm Petri dish with five inoculum plugs from a 4 week old culture of *P. ramorum* (NA1 lineage) grown on V8A. 12 mL of sterile deionized water (sdH_2O) was added to each plate and plates were incubated in the dark at 20˚C for ten days. After incubation, leaf discs were transferred to a 2 mL cryovial containing 1 ml sdH_2O and shaken on a tissue homogenizer for 40 sec to dislodge spores. Leaf material was removed from each vial and the spore suspension was stored at 4˚C. Spores were counted by removing a 30 µl aliquot and placing on a microscope slide with an 18 mm^2 coverslip. All sporangia and chlamydospores under the coverslip were counted. Five counts were performed per sample, and there were three replicate samples per plant species. Spore counts were normalized to leaf area and total spore counts were expressed as spores/ml.

Table 2. Infection frequency, percent *P. ramorum* isolated from surface-sterilized inoculation sites on leaves, and asymptomatic infection rate on eight common plants in Washington forests and riparian areas. Values are from all treatments (n=20). Columns with different letters are significantly different at p = 0.05 (Chi-squared test, nonparametic multiple comparisons).

Common name	Infection frequency, %	% isolated	Asymptomatic infection, %
Salal	0.58 b	0.55 abc	0.15 b
Pacific madrone	0.78 b	0.65 bc	0.05 ab
Pacific rhododendron	0.75 b	0.70 c	0.00 a
Oregon grape	0.58 b	0.78 c	0.08 ab
Himalayan blackberry	0.15 a	0.35 ab	0.25 b
California bay laurel	0.60 b	0.85 c	0.10 ab
English laurel	0.68 b	0.55 abc	0.00 a
English ivy	0.13 a	0.28 a	0.10 ab

Results

Susceptibility

In both wounded and non-wounded treatments, lesions developed on the lower leaf surface (70%) more often than the upper surface (33%) on all plant species tested. The unwounded upper surface was infected least often (5%). Only two species, Pacific madrone and California bay laurel, became infected on the upper surface without wounding. The most susceptible species was Pacific madrone, but this may have been because juvenile foliage was used. Foliage from mature trees will be tested in future experiments. Pacific rhododendron was also highly susceptible to infection by *P. ramorum* (Table 2). The introduced species Himalayan blackberry and English ivy were the most resistant.

While visible symptoms were not seen on some hosts, *P. ramorum* was isolated from some inoculation sites after surface sterilization. These asymptomatic infections occurred 25% of the time on Himalayan blackberry and 10% of the time on California bay laurel. There was no asymptomatic infection on English laurel and Pacific rhododendron. Asymptomatic infection occurred at a very low rate on Pacific madrone and Oregon grape (Table 2).

Inoculum survival was not significantly different on all the hosts, but when treatments were considered, the unwounded upper surface had significantly less inoculum survival than did the other treatments ($p < 0.001$, Chi-squared test, non parametric multiple comparisons).

Sporulation

California bay laurel produced more sporangia per ml than any of the WA forest species tested. When lesion size was taken into account, there were no significant differences in the number of sporangia per lesion among bay laurel, Pacific madrone (juvenile foliage), and Oregon grape. Sporangia produced on Pacific rhododendron and English laurel also did not differ significantly (Table 3). Salal was a poor producer of sporangia, but was comparable to English laurel and Oregon grape in chlamydospore production. The species with the highest chlamydospore count per ml was California bay laurel. Most of the plant species tested were not statistically different from bay laurel in chlamydospores per lesion. The species with the lowest sporulation rates were English ivy and Himalayan blackberry.

When compared with *Rhododendron ponticum*, the species responsible for spreading *P. ramorum* in UK forests, the Washington native *R. macrophyllum* produced significantly fewer sporangia, and similar numbers of chlamydospores. Lesion sizes were also similar (data not shown).

Table 3. Sporulation of *P. ramorum* on several hosts. Both sporangia and chlamydospores were counted. Total spore production is given as sporangia or chlamydospores/ml, and number of spores per lesion is shown. Lesion measurements are from wounded lower leaf surface. Columns with different letters are significantly different at $p = 0.05$ (K-W test, nonparametric multiple comparisons).

PLANT #	Name	Lesion, mm2	Sp /ml	sp/lesion	chl/ml	chl/lesion
2	Salal	18	6 ab	0.3 a	103 ab	7 ab
3	Pacific madrone	788	4 a	10 b	20 a	59 b
4	Pacific rhododendron	377	3 a	4 ab	31 a	40 b
5	Oregon grape	183	11 ab	8 b	77 ab	50 b
7	Himalayan blackberry	1	3 a	0 a	38 a	0.5 a
12	California bay laurel	90	40 b	9 b	151 b	44 b
44	English laurel	71	5 ab	1 ab	101 ab	25 b
45	English ivy	2	4 a	0 a	42 a	0 a

Discussion

Plants were selected based on their abundance in high risk areas of western Washington, namely riparian zones. Salal is the most common native evergreen shrub in Washington forests and the first detection of *P. ramorum* on vegetation outside of a nursery was on salal in June 2009. Lesion size and production of sporangia and chlamydospores on salal were low, suggesting that this host is not a high risk for spreading *P. ramorum* in Washington forests. However, salal is a dominant understory species on wet sites and may potentially still be an epidemiologically important host for *P. ramorum* even though it appears to have relatively limited susceptibility and sporulation potential.

The largest lesions occurred on juvenile foliage of Pacific madrone, but sporulation was lower than what was observed on some other hosts. Large lesions formed on potted madrone seedlings when inoculated on the stem (Hansen et al. 2005), and lesions were very small when madrone logs were inoculated. Bole cankers from *P. ramorum* have not been seen on Pacific madrone in the wild.

Himalayan blackberry forms dense thickets in *P. ramorum* habitat and could potentially be important in pathogen dispersal. Fortunately, this species does not appear to be a strong host for *P. ramorum*, although there was a higher rate of asymptomatic infection (25%) than on other hosts.

English ivy is found in forests and clings to trees. If *P. ramorum* infected this host it could potentially spread and cause bole cankers on susceptible tree species. English ivy seems almost immune to *P. ramorum* infection and, like blackberry, poorly supported sporulation.

Figure 1. Host reaction of English laurel (Prunus laurocerasus) to foliar infection by Phytophthora ramorum. The infected portion of the leaf drops out and can infest soil with chlamydospores.

The third evergreen broadleaf invasive plant, English laurel, grows rapidly in western Washington's climate and has escaped from cultivation into forested areas. It is rather susceptible to *P. ramorum* and is moderate in chlamydospore production, while poor at sporangia production. This host could be an important source of soil inoculum since a host reaction is to create a "shot hole" where the infected portion of the leaf drops out (Figure 1). These lesions produce chlamydospores which could survive in the soil and infect other hosts.

This preliminary study has shown that some Washington forest plants are very susceptible to infection by *P. ramorum*. While detached leaf tests are a good screening tool, further studies using whole plants are needed to determine the risk to these species, since detached leaf tests may not accurately reflect susceptibility in a field situation. Further testing will involve coniferous and deciduous plants, as well as testing other genotypes of *P. ramorum*.

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Proposed Nomenclatural Changes in *Arceuthobium*: Published and Forthcoming.

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Abstract

The taxonomic history for *Arceuthobium* from the early 1800s to the 1990s is summarized. Important publications such as Gill's 1935 monograph for *Arceuthobium* in the United States, Hawkworth and Wiens' 1972 monograph for the entire genus, and Hawksworth and Wiens' 1996 revised monograph are briefly discussed. Since the publication of the 1996 monograph six minor changes in the Hawksworth and Wiens system of classification have been published; four new subspecies have been described and two new combinations have been proposed. Based solely on molecular evidence, a major modification of the classification for *Arceuthobium* was proposed in 2004 which recognized only 26 species instead of the 42 species recognized by Hawksworth and Wiens. Furthermore, there is about to be a new treatment of *Arceuthobium* for the United States and Canada published in the Flora of North America (FNA) based on the 2004 classification. The proposed treatment of *Arceuthobium* for FNA will reduce the recognized species of *Arceuthobium* for the United States to 8 and for Canada to 4, because it groups 12 of the taxa recognized by Hawksworth and Wiens that occur in the West under one species: *A. campylopodum*.

History of the classification of *Arceuthobium* to 1996

Arceuthobium has long been considered a taxonomically difficult genus because of the morphological and phenological similarities between many of the currently recognized species, several of which were described by Frank Hawksworth and Del Wiens from 1964 to 1993. Not only do the dwarf mistletoes have small, scale-like leaves, but their male flowers are similar in form and relatively small (2-5 mm in diameter) and their fruits are also similar (bi-colored and 3-9 mm in length). These characteristics have contributed to the difficulties associated with their taxonomic classification and to their identification by many foresters, botanists, and even forest pathologists. However, because many of the dwarf mistletoes recognized by Hawksworth and Wiens are host specific, knowing the geographic location and correct identification of the host being affected, allows most species of *Arceuthobium* to be easily determined.

The first dwarf mistletoe described was the parasite of junipers which is distributed from southern Europe to China: *Arceuthobium oxycedri*. However, it was initially classified as a species of *Viscum* in 1576, but was reclassified in the early 1800s once it was realized that it was distinct from mistletoes in the genus *Viscum* and that it deserved status in its own genus. This is the time period when the no longer used genus *Razoumofskya* was coined by Hoffman and the juniper dwarf mistletoe was placed under it. However, in 1819 Marschall von Bieberstein proposed the genus *Arceuthobium* for the parasite of junipers in Europe and Asia. Although *Arceuthobium* was then generally adopted in Europe and used throughout the 1800s, it was not officially conserved over *Razoumofskya* until 1905. However, some botanists in the United States continued to recognize *Razoumofskya* until 1930, but after that *Arceuthobium* became the "official" genus for dwarf mistletoes.

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Table 1. Provides an outline of the taxonomic history for *Arceuthobium*. However, there are several important events regarding the nomenclature of the genus that I will discuss in more detail below.

Year	**Descriptions of Species or Subspecies**
1806	Willdenow described *A. vaginatum* collected from Mexico in 1804 as *Viscum vaginatum*.
1808	*A. oxycedri* originally classified as a species of *Razoumofskya* by Hoffman.
1819	Marschall von Bieberstein proposed *Arceuthobium* as the genus for dwarf mistletoes.
1825	Presl recombined *Viscum vaginatum* as *Arceuthobium vaginatum*.
1850	Engelmann described *A. americanum*, *A. campylopodum*, and *A. cryptopodum* in the U.S.
1871	Engelmann described *Arceuthobium minutum* (= *A. pusillum*).
1872	Peck described *A. pusillum* from New York and Engelmann described *A. abietinum* from California.
1878	Engelmann described *A. douglasii*, *A. douglasii* var. *microcarpum*, *A. divaricatum*, and *A. occidentale*.
1880	Engelmann described *Arceuthobium verticilliflorum* from northern Mexico.
1886	Hooker described *Arceuthobium minutissimum* from Nepal.
1906	Piper described *Razoumofskya douglasii* subsp. *laricis* from Washington (= *A. laricis*).
1909	Nelson described *Arceuthobium cyanocarpum* from Wyoming.
1911	Chiovenda described *Arceuthobium juniperi-procerae* from Ethiopia.
1912	Urban described *Arceuthobium bicarinatum* from the Dominican Republic (Hispaniola).
1913	Nelson described *Arceuthobium blumeri* from Arizona.
1915	Lecomte described *Arceuthobium chinense* from China.
1923	Heil described *Arceuthobium abietis-religiosae* from central Mexico.
1935	Gill published the first comprehensive monograph for *Arceuthobium* in the U.S. Gill recognized 5 species and 8 host forms under *A. campylopodum*.
1937	St. John recombined Piper's *R. douglasii* subsp. *laricis* as *Arceuthobium laricis*.
1964	Hawksworth and Wiens described *Arceuthobium gillii* from Arizona.
1965	Hawksworth and Wiens described *A. globosum*, *A. rubrum*, *A. strictum*, *A. gillii* subsp. *nigrum*, and *A. vaginatum* subsp. *durangense* from northern Mexico. They recombined Engelmann's *A. cryptopodum* as *A. vaginatum* subsp. *cryptopodum*.
1970	Hawksworth and Wiens described *A. apachecum*, *A. californicum*, *A. guatemalense*, *A. hondurense*, and *A. pini*.
They	designated the *A. abietinum* populations on white fir as a special form: *A. abietinum* formae specialis *concoloris* and those on red fir as f. sp. *magnificae*. They also recombined Engelmann's *A. douglasii* var. *microcarpum* as *A. microcarpum*.
1972	Hawksworth and Wiens published their first comprehensive monograph of *Arceuthobium* in which they recognized 28 species, 5 subspecies, and two special forms.
1976	Hawksworth and Wiens described *A. azoricum* from the Azores and recognized *A. juniperi-procerae* as a valid species (see 1911 above).
1977	Hawksworth and Wiens segregated *A. globosum* into four taxa: *A. globosum* subsp. *globosum*, *A. globosum* subsp. *grandicaule*, *A. aureum* subsp. *aureum*, and *A. aureum* subsp. *petersonii*.
1980	Hawksworth and Wiens described *A. pendens* from central Mexico.
1984	Kiu described *A. pini* var. *sichuanense* from southwestern China.
1989	Hawksworth and Wiens described *A. yecorense* from Sonora, Mexico and *A. oaxacanum* from southern Mexico. They recombined *A. vaginatum* subsp. *durangense* and *A. gillii* subsp. *nigrum* as species: *A. durangense* and *A. nigrum*.
1992	Hawksworth, Wiens, and Nickrent described *A. littorum*, *A. monticola*, and *A. siskiyouense* from northern California. Hawksworth and Nickrent described *A. tsugense* subsp. *mertensianae*.
1993	Hawksworth and Wiens recombined Kiu's *A. pini* var. *sichuanense* as *A. sichuanense*.
1994	Wiens and Shaw described *A. hawksworthii* from Belize.
1996	Hawksworth and Wiens published their revised monograph of *Arceuthobium* in which they recognized 42 species, 4 subspecies, one race, and two special forms.

George Engelmann was the first to describe a species of *Arceuthobium* in the United States; *A. americanum* in 1850. Because Engelmann described most of the species of *Arceuthobium* known from the U.S. and Canada up to the 1930s he has been considered the "father" of *Arceuthobium* classification in the United States (Table 2).

Table 2. George Engelmann's classification of *Arceuthobium* in the United States.

Species	Year Described	Synonym
A. abietinum	1872	
A. americanum	1850	
A. campylopodum	1850	
A. cryptopodum	1850	*A. vaginatum* subsp. *cryptopodum*
A. divaricatum	1878	
A. douglasii	1878	
A. douglasii var. microcarpum	1878	*A. microcarpum*
A. minutum	1871	*A. pusillum*
A. occidentale	1878	

In the early 1900s several new species of *Arceuthobium* were described (Table 1). In the United States this is the era when *A. laricis*, *A. cyanocarpum*, and *A. blumeri* were discovered.

The first monographic treatment of *Arceuthobium* for the United States was by Lake Gill in 1935 in which he separated *A. campylopodum* and *A. vaginatum* into forms solely based on host relationships. This has been referred to as Gill's "host form concept." Gill also recognized well defined species such as *A. americanum*, *A. douglasii*, and *A. pusillum*, but he chose to group several dwarf mistletoes (including *A. abietinum*, *A. blumeri*, *A. cyanocarpum*, *A. divaricatum*, *A. laricis*, and *A. microcarpum*) as host forms of *A. campylopodum*. Gill's host form system classified any dwarf mistletoe parasitizing a true fir (*Abies* spp.) as *A. campylopodum* forma *abietinum*; it didn't matter if the mistletoe was also severely parasitizing a hemlock (*Tsuga* spp.) in the same locality. Even when the mistletoe on the true fir morphologically resembled the plants on the hemlock, these mistletoes were classified as different host forms of *A. campylopodum*: the mistletoe on the true fir was forma *abietinum* and the mistletoe on the hemlock was forma *tsugensis* under Gill's host form concept. The inadequacies of this system were soon apparent to anyone trying to sort out the host affinities of dwarf mistletoes which usually parasitize a principal host, but frequently cross infect other hosts in the same stand to a lesser degree.

Few changes occurred in the nomenclature of *Arceuthobium* after Gill published his classic paper until Hawkworth and Wiens described *A. gillii* in 1964 (Table 1). Then in 1965, Hawksworth and Wiens described five new taxa of *Arceuthobium* from northern Mexico: *A. globosum*, *A. rubrum*, *A. strictum*, *A. gillii* subsp. *nigrum*, and *A. vaginatum* subsp. *durangense*. They also "re-discovered" a species that had been almost completely ignored since it had been originally described from Durango by Engelmann in 1880: *A. verticilliflorum*. They also acknowledged the classification of the dwarf mistletoe from central Mexico on sacred fir (*Abies religiosa*) described by Heil in 1923: *A. abietis-religiosae*.

Hawksworth and Wiens continued their taxonomic studies of *Arceuthobium* in the late 1960s and in 1970 they described five new species: *A. apachecum* (Southwestern U.S.), *A. californicum* (California), *A. guatemalense* (Guatemala), *A. hondurense* (Honduras), and *A. pini* (China). They also recognized *A. abietinum* as a valid species (see Table 2), but classified the populations only infecting white fir (*Abies concolor*) and those only infecting red fir (*A. magnifica*) as special forms: *A. abietinum* formae specialis *concoloris* and formae specialis *magnificae*. They used the special form designation because they maintained there were no major morphological differences between the shoots produced on white fir versus those on red fir, yet Dick Parmeter and Bob Scharpf had clearly demonstrated the two special forms would not cross infect the other fir host. This fascinating host specialization by fir dwarf mistletoe appears to hold true in the Sierra Nevada Mountains, but as I will mention below it is not operating in the true fir stands of the Klamath-Siskiyou Mountains in northwestern California and southwestern Oregon.

In 1972 Hawksworth and Wiens published their first taxonomic monograph of *Arceuthobium* which became the authoritative publication on the biology and taxonomy of the genus for many years. In it they recognized 28 species, 5 subspecies, and the two special forms of *A. abietinum*. All of the species of *Arceuthobium* mentioned above were included in this monograph, including the recognition of the species described by Engelmann in the 1800s (see Table 2), except that Engelmann's *A. minutum* was treated as *A. pusillum* which was described by Peck in 1872 and *A. juniperi-procerae* was not recognized by Hawksworth and Wiens until 1976. In their 1972 monograph Hawksworth and Wiens used morphology (shoot size and color, flower and fruit characters), phenology (time of meiosis, flowering and seed dispersal), palynology (pollen characters), chemical constituents (anthocyanins and flavanoids), cytology (chromosome characters), and host relationships and reactions (host range and host response to infection) in support of their treatment of *Arceuthobium*. They also used the first taximetric analysis of the genus as another approach to support their classification. Furthermore, Hawksworth and Wiens discussed their concepts for the classification of species, subspecies, and special forms in *Arceuthobium*, discussed the importance of the life history of dwarf mistletoes in their classification, and elucidated the importance of differences in host specificity between dwarf mistletoe populations and how these differences could be applied to the classification of morphologically and phenologically similar species or subspecies. Another key, but controversial convention, that Hawksworth and Wiens developed was the use of the dimensions of the third internode of shoots as a morphological character for the comparison of taxa. Although the use of this character (length and width of the third internode) has been criticized, I think it is useful in that it provides a quantitative means of assessing to some degree the amount of "taper" and/or the general "thickness" of dwarf mistletoe shoots.

Hawksworth and Wiens remained the most active taxonomic investigators of *Arceuthobium* from the early 1970s into the 1990s (Table 1). They continued their studies of dwarf mistletoes in Mexico and Central America, particularly the populations they treated as *A. globosum*, and in 1977 they separated this species into several new taxa: *A. globosum* subsp. *globosum*, *A. globosum* subsp. *grandicaule*, *A. aureum* subsp. *aureum*, and *A. aureum* subsp. *petersonii*. Next, after several trips to Mexico looking for a reported dwarf mistletoe parasitizing pinyons they discovered it in San Luis Potosi and described it as *A. pendens* in 1980.

Nearly 10 years passed before Hawksworth and Wiens discovered another dwarf mistletoe new to science in northern Mexico which they described as *A. yecorense* in 1989. In this paper they also described the populations of what they had earlier classified as *A. rubrum* in Oaxaca, Mexico as a new species: *A. oaxacanum*. Furthermore, they raised two subspecies, *A. vaginatum* subsp. *durangense* and *A. gillii* subsp. *nigrum* to specific rank as *A. durangesne* and *A. nigrum*.

The last taxonomic efforts Hawksworth and Wiens completed together were in the early 1990s. , In 1992, working in cooperation with Dan Nickrent, Hawksworth, Wiens, and Nickrent described two new species of *Arceuthobium* from northern California that they had originally aligned in 1972 with *A. campylopodum*: *A. littorum* and *A. siskiyouense*. They also classified the populations parasitizing western white pine (*Pinus monticola*) in northern California and southern Oregon as *A. monticola*, which they separated from *A. californicum* which parasitizes sugar pine (*Pinus lambertiana*). They also separated the dwarf mistletoe populations parasitizing mountain hemlock (*Tsuga mertensiana*) from the populations on western hemlock (*Tsuga heterophylla*) as a subspecies of hemlock dwarf mistletoe: *A. tsugense* subsp. *mertensianae*. Furthemore, they designated the populations of hemlock dwarf mistletoe parasitizing shore pine (*P. contorta* var. *contorta*) in British Columbia and northern Washington as a race of western hemlock dwarf mistletoe (*A. tsugense* subsp. *tsugense*). This classification of shore pine dwarf mistletoe became the only application of the race concept in *Arceuthobium* and remains so today. In 1993, after examining several herbarium specimens of a dwarf mistletoe that had been described from China as *A. pini* var. *sichuanense* in 1984, Hawksworth and Wiens decided it was distinctive enough from *A. pini* to be given specific status as *A. sichuanense*.

Even though Frank Hawksworth died in January 1993, the classification of *A. sichuanense* was not to be Hawksworth and Wiens' final work together. Frank and Del had been working for several years on a revision of their 1972 monograph of *Arceuthobium* and in 1993 it was nearing completion. However, before their revised monograph was published, Del Wiens and Terry Shaw traveled to Central America to examine populations of *A. aureum* there. Based on their morphological analyses and a comparison of the host ranges and host responses between the Guatemalan and Belizean populations of *A. aureum*, they described the populations on Caribbean pine (*Pinus caribaea* var. *hondurensis*) in Belize as a new species commemorating Frank Hawksworth: *Arceuthobium hawksworthii*. Then with the dedicated efforts of several people who wished to see the publication of the revised *Arceuthobium* monograph come to fruition, including Del Wiens, Terry Shaw, and particularly Brian Geils, the revision was published in 1996.

In the 1996 monograph of *Arceuthobium*, Hawksworth and Wiens recognized 46 taxa comprised of 42 species, four of which had two subspecies each, one race of *A. tsugense*, and the two special forms of *A. abietinum* were retained (Table 3). Eight species were recognized that occur in the Old World and 34 species were recognized from the New World. The revised monograph provided systematic and descriptive information for each species and subspecies as well as detailed information on the biology, anatomy, physiology, ecological relationships, pathology, and management of dwarf mistletoes. This work remains the most definitive publication on all aspects of *Arceuthobium* history, biology, and systematics, even though it is nearing 15 years since it was printed.

Table 3. Classification proposed for *Arceuthobium* by Hawksworth and Wiens in 1996. Species grouped by major geographic regions.

United States and Canada	Mexico and Central America	Europe and Africa	Asia
A. abietinum	*A. abietis-religiosae*	*A. azoricum*	*A. chinense*
f. sp. *concoloris* [1]	*A. aureum*	*A. juniperi-procerae*	*A. minutissimum*
f. sp. *magnificae*	*A. aureum* subsp. *petersonii*	*A. oxycedri* [3]	*A. pini*
A. americanum	*A. bicarinatum*		*A. sichuanense*
A. apachecum [1]	*A. blumeri* [2]		*A. tibetense*
A. californicum	*A. durangense*		
A. campylopodum [1]	*A. globosum*		
A. cyanocarpum	*A. globosum* subsp. *grandicaule*		
A. divaricatum	*A. guatemalense*		
A. douglasii [1]	*A. hawksworthii*		
A. gillii [1]	*A. hondurense*		
A. laricis	*A. nigrum*		
A. littorum	*A. oaxacanum*		
A. microcarpum	*A. pendens*		
A. monticola	*A. rubrum*		
A. occidentale	*A. strictum*		
A. pusillum	*A. vaginatum*		
A. siskiyouense	*A. verticilliflorum*		
A. tsugense	*A. yecorense*		
A. tsugense subsp. *mertensianae*			
A. vaginatum subsp. *cryptopodum* [1]			

[1] – also occurs in Mexico; [2] – also occurs in the United States; [3] – also occurs in Asia.

Classification of *Arceuthobium* Post Hawksworth and Wiens

Essentially, no new species of *Arceuthobium* have been discovered and described since Hawksworth and Wiens' 1996 monograph. But four new subspecies have been described, two new combinations have been published, and a completely new classification of *Arceuthobium* based almost entirely on molecular evidence has been proposed by Dan Nickrent.

In 2003, Ed Wass and I raised the shore pine race of hemlock dwarf mistletoe to subspecific rank based on morphological, phenological, and host range differences between western hemlock dwarf mistletoe (*A. tsugense* subsp. *tsugense*) and shore pine dwarf mistletoe (*A. tsugense* subsp. *contortae*). This allows for an alternative classification of the shore pine dwarf mistletoe that does not use the race designation. Shore pine dwarf mistletoe differs from western hemlock dwarf mistletoe in several ways. Shoots of shore pine dwarf mistletoe are shorter on average, greenish-brown in color, its flowers are larger, and it only occasionally infects western hemlock (Table 4). Furthermore, in stands where both shore pine and western hemlock dwarf mistletoes co-occur on Vancouver Island, shore pine dwarf mistletoe consistently reaches its peak in seed dispersal one week before western hemlock dwarf mistletoe. Although the classification of shore pine dwarf mistletoe at the subspecific rank does not conform perfectly to Hawksworth and Wiens' concept of a subspecies (it co-occurs with subsp. *tsugense* so these two subspecies are not geographically isolated), because it has definite morphological and physiological differences from western hemlock dwarf mistletoe, it is better to treat it as a subspecies than as a race, which by definition would mean that the shore pine and western hemlock dwarf mistletoe races are morphologically identical. They are not and our morphological data, much of which indicated there were statistically significant differences between the characters measured, demonstrated this.

Table 4. Comparison of western hemlock dwarf mistletoe (*A. tsguense* subsp. *tsugense*) and shore pine dwarf mistletoe (*A. tsugense* subsp. *contortae*) from Wass and Mathiasen (2003).

Characters	Subsp. *tsugense*	Subsp. *contortae*
Mean Plant Height (cm):		
Male	7.8	5.6
Female	8.0	6.6
Plant Color:		
Male	green-brown	yellow-green
Female	green-brown	yellow-green/purple
Mean Flower Diameter (mm)	4.3	3.6
Host Susceptibility:		
Shore Pine	Occasional	Principal
Western Hemlock	Principal	Occasional
Peak Seed Dispersal	One week later than subsp. *contortae*	One week earlier than subsp. *tsugense*

A major change in the classification of *Arceuthobium* was essentially proposed by Dr. Dan Nickrent in 2004. Dr. Nickrent and his colleagues from Spain completed their molecular analyses of all species of *Arceuthobium* for two molecular markers, nuclear ribosomal internal transcribed spacer (ITS) sequences (all species) and chloroplast *trnT-L-F* sequences (New World species only), which Dr. Nickrent then used to develop dendrograms using maximum parsimony analyses. He then interpreted his molecular data as being evidence that a new classification that better reflected the phylogenetic relationships between species was needed. He argued that the molecular data provided a more reliable means of determining the phylogeny of *Arceuthobium*. Because his classification only recognized monophyletic species that were differentiated solely by molecular data, it recognized just 26 species of *Arceuthobium*, no subspecies and no special forms of *A. abietinum* (Table 5). Several species recognized by Hawksworth and Wiens were grouped together because the DNA sequences in the molecular regions Dr. Nickrent examined were very similar. Because this classification is only based on molecular data and does not account for morphological or physiological (phenology, chemistry, and host affinities) differences between dwarf mistletoe populations, its practical application by forest pathologists is difficult, if not impossible. This is primarily because the classification groups the species recognized by Hawksworth and Wiens that are among the most economically important taxa all under one species: *A. campylopodum* (Table 5). This includes *A. abietinum* on true firs, *A. californicum* on sugar pine, *A. laricis* on western larch, and *A. tsugense* on hemlocks.

Table 5. Classification of *Arceuthobium* proposed by Nickrent in 2004 based on molecular data.

United States and Canada	Mexico and Central America	Europe and Africa	Asia
A. americanum	*A. abietis-religiosae*	*A. azoricum*	*A. chinense*
A. campylopodum	*A. bicarinatum*	*A. juniperi-procerae*	*A. minutissimum*
A. divaricatum	*A. blumeri*	*A. oxycedri*	*A. pini*
A. douglasii	*A. globosum*		*A. sichuanense*
A. gillii	*A. guatemalense*		*A. tibetense*
A. pusillum	*A. hondurense*		
	A. pendens		
	A. rubrum		
	A. strictum		
	A. vaginatum		
	A. verticilliflorum		
	A. yecorense		

Few investigators have adopted the Nickrent classification thus far, but it is being referenced in some papers related to mistletoes in general and I have reviewed one paper that adopted it throughout the article. The adoption of Nickrent's classification in that article led to a good deal of confusion, particularly in the introduction and discussion sections. When the author referred to previous work on *A. abietinum*, they called the fir dwarf mistletoe *A. campylopodum*. Anyone reading the article with knowledge about *A. campylopodum* would know it is primarily a parasite of ponderosa pine and Jeffrey pine (*Pinus jeffreyi*) and not a parasite of true firs. Forest pathologists need to be aware of Nickrent's alternative classification for *Arceuthobium* that has been published as they may see it beginning to be used more often (see below). However, I still don't perceive that the Nickrent classification is going to replace the Hawksworth and Wiens classification for *Arceuthobium*.

Since 1997, I have been collecting additional morphological, phenological, and host range data for several dwarf mistletoe populations in the western U.S., Mexico, and Central America. My objective has been to use more detailed morphological and host range data than was collected by Hawksworth and Wiens during their investigations of these populations in order to "fine tune" the *Arceuthobium* classification system they developed.

Based on my field work in Oregon I discovered there were populations of hemlock dwarf mistletoe that were primarily parasitizing Pacific silver fir (*Abies amabilis*), noble fir (*A. procera*), and mountain hemlock that were being confused with mountain hemlock dwarf mistletoe (*A. tsugense* subsp. *mertensianae*) by Hawksworth and Wiens. After 10 years of work on these populations, during which I collected a large amount of additional morphological data for many populations of western hemlock dwarf mistletoe (subsp. *tsugense*) and mountain hemlock dwarf mistletoe (subsp.

mertensianae), as well as for the mistletoe on Pacific silver fir, I concluded that the dwarf mistletoe on Pacific silver fir deserved taxonomic recognition as a new subspecies. Because my wife, Carolyn Daugherty, assisted me with much of the work on the mistletoe affecting Pacific silver fir and noble fir in central Oregon, we described this new subspecies in the journal Novon in 2007 as *A. tsugense* subsp. *amabilae*.

Pacific silver fir dwarf mistletoe has larger shoots than both western and mountain hemlock dwarf mistletoes and it only occasionally infects western hemlock (Table 6). Although it also severely parasitizes mountain hemlock, its shoots are more than twice as large as typical mountain hemlock dwarf mistletoe. Pacific silver fir dwarf mistletoe is distributed in Oregon from Mt. Hood to as far south as the Umpqua River watershed. The mistletoe parasitizing noble fir on Mary's Peak near Corvallis, OR was classified as a western outlier of Pacific silver fir dwarf mistletoe. The Pacific silver fir dwarf mistletoe severely parasitizes both Pacific silver fir and noble fir, particularly in the vicinity of the H. J. Andrews Experimental Forest.

Table 6. Comparison of the principal differences between Pacific silver fir dwarf mistletoe (*A. tsugense* subsp. *amabiliae*), western hemlock dwarf mistletoe (*A. tsugense* subsp. *tsugense*), and mountain hemlock dwarf mistletoe (*A. tsugense* subsp. *mertensianae*) from Mathiasen and Daugherty (2007).

Characters	Subsp. *amabilae*	Subsp. *tsugense*	Subsp. *mertensianae*
Mean Plant Height (cm)			
Male	9.4	7.8	5.7
Female	10.6	8.0	6.1
Mean Basal Diameter (mm)			
Male	3.1	2.6	1.9
Female	3.4	2.7	2.2
Mean Flower Diameter (mm)	3.5	3.6	2.7
Host Susceptibility			
Pacific Silver Fir	Principal	Occasional	Immune
Western Hemlock	Occasional	Principal	Occasional
Mountain Hemlock	Principal	Occasional	Principal
Noble Fir	Principal	Occasional	Unknown
Western White Pine	Rare	Rare	Occasional

In 1998 Catherine Parks, Jerry Beatty, and I started field studies of *Arceuthobium hawksworthii* in the Mountain Pine Ridge area of Belize. We also visited Honduras to examine populations of *A. hondurense* there and noted many similarities between the Honduran dwarf mistletoe and Hawksworth's dwarf mistletoe in Belize. Both dwarf mistletoes had large male plants that were often green to green-brown with reddish flowers. We then began a more detailed morphological analysis of *A. hawksworthii* and *A. hondurense* and published the results of our preliminary findings in 1999. After discovering *A. hondurense* in Chiapas and Oaxaca, Mexico we expanded our work to southern Mexico. I completed several additional trips to Chiapas, Honduras, and

Belize and collected a large amount of extra morphological and host range data for both dwarf mistletoes. In 2001 I discovered *A. hawksworthii* in north-central Honduras on Caribbean pine, but it did not parasitize eggcone pine (*Pinus oocarpa*) in Honduras, the principal host of *A. hondurense* there. After comparing the morphological, phenological, and host range data I had gathered for *A. hawksworthii* and *A. hondurense*, and after learning that the nuclear ribosomal ITS sequences were similar for these species from Dan Nickrent, I published a new combination for *A. hawksworthii* as a subspecies of *A. hondurense*: *A. hondurense* subsp. *hawksworthii*. The subspecies of *A. hondurense* have several similar characteristics, but differ in their plant size, plant color, flowering period, and host range (Table 7).

Table 7. Comparison of the principal differences between *A. hondurense* subsp. *hondurense* and *A. hondurense* subsp. *hawksworthii* from Mathiasen (2007).

Characters	Subsp. *hondurense*	Subsp. *hawksworthii*
Mean Plant Height (cm)		
Male	18.9	16.5
Female	25.8	15.8
Mean Basal Diameter (mm)		
Male	5.8	3.8
Female	5.2	3.7
Mean Fruit Length & Width (mm)	5.3 x 3.5	4.6 x 2.9
Anthesis Period	August-November	December-March
Seed Dispersal Period	September-October	November-January
Host Susceptibility		
Pinus oocarpa	Principal	Immune
Pinus tecunumanii	Principal	Secondary
Pinus caribaea var. *hondurensis*	Unknown	Principal

Another group of dwarf mistletoes that are very similar is the *A. globosum* complex consisting of *A. globosum* and its subspecies *grandicaule* and *A. aureum* and its subspecies *petersonii*. In 2001 I began collecting additional morphological, phenological, and host range data for these mistletoes from northern Mexico (*A. globosum*), central and southern Mexico and Guatemala (subsp. *grandicaule*), Guatemala (*A. aureum*), and from Chiapas and Oaxaca, Mexico (*A. aureum* and subsp. *petersonii*, and subsp. *grandicaule*). My analyses of morphological measurements for these taxa indicated that *A. aureum* and its subspecies *petersonii* were more similar to *A. globosum* than reported by Hawksworth and Wiens in 1977. Furthermore, ITS data again indicated they were very similar so I recombined *A. aureum* and its subspecies *petersonii* under *A. globosum*. Under this classification all of the dwarf mistletoe populations resembling *A. globosum* in Mexico and Central America are treated as subspecies of this taxon: *A. globosum* subsp. *globosum*, subsp. *grandicaule*, subsp. *aureum*, and subsp. *petersonii*. This is a minor change in the classification followed by Hawksworth and Wiens, but I believe it better reflects the relationships of these dwarf mistletoe populations. More work is needed on the populations of subsp. *grandicaule*, subsp. *petersonii*, and subsp. *aureum* in Chiapas, Mexico where all three subspecies occur and where subsp. *grandicaule* and *petersonii* co-occur in pine stands near San Cristobal de las Casas. These subspecies are morphologically similar, but subsp. *petersonii* has much smaller staminate flowers, narrower staminate spikes, and flowers in August and September, whereas subsp. *grandicaule* flowers in the late winter to early spring.

In 1997 I was shown a population of fir dwarf mistletoe by Gregg DeNitto on Brewer spruce (*Picea breweriana*) northwest of Happy Camp, CA. The plants of the mistletoe were green-brown to reddish to nearly orange in color and it was severely infecting Brewer spruce and red fir and only occasionally infecting white fir in the same stands. At that time, three different dwarf mistletoes were known to infect Brewer spruce to some degree: *A. abietinum* f. sp. *concoloris*, *A. monticola*, and *A. tsugense* subsp. *mertensianae*. But Brewer spruce was not considered to be a principal host of any these dwarf mistletoes. Therefore, I began additional morphological, phenological, and host range studies of these mistletoes in 1998.

After several years of collecting data in southwestern Oregon and northwestern California, I found that Brewer spruce is a principal host for *A. abietinum*, *A. monticola*, and *A. tsugense* subsp. *mertensianae*; but populations of the mistletoes are not common on Brewer spruce within its limited range in the Klamath-Siskiyou Geological Province. Although it was clear when *A. monticola* and *A. tsguense* subsp. *mertensianae* were infecting Brewer spruce because their other principal hosts were also infected in the same stand, it was not clear which special form of *A. abietinum* was parasitizing Brewer spruce. Because red firs were severely infected when growing near severely infected Brewer spruces, by definition the mistletoe was not *A. abietinum* f. sp. *concoloris* although this is the species that Hawkworth and Wiens classified it as. This was evidently not an obvious case of just reclassifying the mistletoe as *A. abeitinum* f. sp. *magnificae* because the mistletoe also infected white fir in the same stands where red fir and Brewer spruce were infected, but white fir was much less severely infected than either of these other hosts. This was evidence that these stands were not infested by both *A. abietinum* f. sp. *concoloris* and f. sp. *magnificae*. Furthermore, at several locations where I observed severe infection of white fir in northwestern CA by f. sp. *concoloris*, associated Brewer spruce growing near severely infected white firs were not infected. On the other hand, wherever I found infection of red fir, closely associated Brewer spruces were also severely infected.

In 2008 I expanded my field work to include collecting additional morphological data for *A. abietinum* f. sp. *concoloris* and f. sp. *magnificae* throughout their geographic ranges. I collected morphological data for f. sp. *concoloris* from southern WA through OR and CA and into NV. I collected morphological data for f. sp. *magnificae* from southwestern OR and northwestern CA and through the Sierra Nevada Mountains to as far south as Yosemite National Park. I also examined red fir stands for dwarf mistletoe north of Lassen National Park, around Mt. Shasta, and near Mt. Eddy. I did not find any populations of red fir dwarf mistletoe in those areas, but the mistletoe is present northwest of those locations near Etna and southwest of there on South Fork Mountain. Red fir dwarf mistletoe is then distributed north of those locations through the Klamath-Siskiyou Mountains into southwestern OR. However, these populations of red fir dwarf mistletoe infect red fir, Brewer spruce, and occasionally infect white fir. I found several locations where both red fir and white fir were infected, but the white fir was consistently infected much less than red fir, again indicating that these were not locations where both red fir and white fir dwarf mistletoes co-occurred.

Table 8. Comparison of the principal differences between Wiens' dwarf mistletoe (*A. abietinum* subsp. *wiensii*), white fir dwarf mistletoe (*A. abietinum* f. sp. *concoloris*), and red fir dwarf mistletoe (*A. abietinum* f. sp. *magnificae*) from Mathiasen and Daugherty (2009).

Characters		Subsp. *wiensii*	F. Sp. *concoloris*	F. Sp. *magnificae*
Mean Plant Height (cm)				
	Male	8.9	12.2	11.6
	Female	9.5	12.0	11.8
Mean Basal Diameter (mm)				
	Male	3.1	3.6	3.5
	Female	3.2	3.7	3.6
Plant Color	Male	green-brown; red-brown; orange	yellow-green; yellow	yellow-green; yellow; green-brown
	Female	green-brown; red-brown	yellow-green; yellow	yellow-green; yellow; green-brown
Mean Flower Diameter (mm)				
3-merous Flowers		2.4	2.6	2.7
4-merous Flowers		3.2	3.5	3.5
Mean Fruit Length (mm)		4.2	4.7	4.6
Host Susceptibility				
White Fir		Occasional	Principal	Immune
Red Fir		Principal	Immune	Principal
Brewer Spruce		Principal	Immune	Unknown
Western White Pine		Rare	Rare	Unknown

After comparing morphological data for all of the fir dwarf mistletoe populations I had sampled with those of the dwarf mistletoe populations on Brewer spruce and red fir, I concluded that the populations parasitizing Brewer spruce, red fir, and occasionally white fir were sufficiently different morphologically and physiologically (host preferences) to describe them as a new subspecies of *A. abietinum*. However, instead of naming the subspecies based on its principal host or geographic distribution, I decided to commemorate the work of Del Wiens on *Arceuthobium* and described it as *A. abietinum* subsp. *wiensii* (Wien's dwarf mistletoe). The description of Wiens' dwarf mistletoe is about to be published in Madroño in September 2009. Wiens' dwarf mistletoe differs from the special forms of *A. abietinum* in that its plant are smaller, its plant color, and its ability to infect Brewer spruce, red fir, and occasionally white fir (Table 8). I have quantitative infection data collected in stands where Brewer spruce, red fir, and white fir were infected which supports the classification of Brewer spruce and red fir as principal hosts and white fir as an occasional host using the host susceptibility system developed by Hawksworth and Wiens. Wiens' dwarf mistletoe also rarely parasitizes western white pine. Wiens' dwarf mistletoe is distributed from South Fork Mountain north through the Klamath-Siskiyou Mountains to about 25 miles west of Grants Pass, OR on Flat Top Mountain.

The other subspecies of *Arceuthobium* that has been described recently is represented by populations of western spruce dwarf mistletoe (*A. microcarpum*) that are infecting Rocky Mountain bristlecone pine (*Pinus aristata*) on the San Francisco Peaks near Flagstaff, AZ. I began taxonomic studies of these populations in 1974 and Jared Scott recently continued my work as a Masters student at Northern Arizona University. In 1975 and 1976 I collected morphological, phenological, and host range data for western spruce dwarf mistletoe throughout its range in Arizona and New Mexico. Jared collected additional data in 2006 and 2007, he then compared both data sets, and concluded that there were sufficient morphological and physiological differences between the populations of *A. microcarpum* on the San Francisco Peaks and nearby Kendrick Peak from other populations in Arizona and New Mexico to describe a new subspecies: *A. microcarpum* subsp. *aristatae*. Jared chose to name this subspecies based on its principal host and just published the description in the Journal of the Texas Botanical Institute in July 2009. Bristlecone pine dwarf mistletoe differs from western spruce dwarf mistletoe by its smaller shoots, different shoot color, earlier flowering period, and its affinity for bristlecone pine (Table 9).

Table 9. Comparison of the principal differences between western spruce dwarf mistletoe (*A. microcarpum* subsp. *microcarpum*) and bristlecone pine dwarf mistletoe (*A.microcarpum* subsp. *aristatae*) from Scott and Mathiasen (2009).

Characters		Subsp. *microcarpum*	Subsp. *aristatae*
Mean Plant Height (cm)			
	Male	5.6	2.7
	Female	6.4	3.6
Plant Color	Male	Light green; green-brown; blue-green	Light green; green-brown; purple
Peak Anthesis Period		1-2 weeks later	1-2 weeks earlier
Host Susceptibility			
	Bristlecone Pine	Unknown	Principal
	Engelmann Spruce	Principal	Occasional
	Blue Spruce	Principal	Unknown
	Limber Pine	Rare	Rare
	Southwestern White Pine	Unknown	Immune

Table 10 summarizes the minor changes I and my co-workers have proposed to the Hawksworth and Wiens classification for *Arceuthobium* since 2003. Note that I have also classified *A. durangese* as *A. vaginatum* subsp. *durangense* which is the original classification for these populations that occur in Durango and Sinaloa, Mexico by Hawksworth and Wiens in 1970 and 1972. I also treat *A. oaxacanum* as conspecific with *A. rubrum* as did Hawksworth and Wiens in 1977. This is based on recent work we completed on the morphological and phenological characteristics of populations in Oaxaca and Durango, Mexico. Our data indicated there were few statistically significant differences between the morphological characters we measured for the populations of *A. oaxacanum* and *A. rubrum* we sampled, so I recommend that these populations all be recognized as *A. rubrum*.

Table 10. Classification proposed for *Arceuthobium* by Hawksworth and Wiens with modifications proposed by Mathiasen and coworkers from 2003 to 2009. Species grouped by major geographic regions.

United States and Canada	Mexico and Central America	Europe and Africa	Asia
A. abietinum	*A. abietis-religiosae*	*A. azoricum*	*A. chinense*
f. sp. *concoloris* [1]	*A. bicarinatum*	*A. juniperi-procerae*	*A. minutissimum*
f. sp. *magnificae*	*A. blumeri* [2]	*A. oxycedri* [3]	*A. pini*
A. abietinum subsp.	*A. globosum* subsp.		*A. sichuanense*
wiensii	*aureum*		*A. tibetense*
A. americanum	*globosum*		
A. apachecum [1]	*grandicaule*		
A. californicum	*petersonii*		
A. campylopodum [1]	*A. guatemalense*		
A. cyanocarpum	*A.hondursense* subsp.		
A. divaricatum	*hawksworthii*		
A. douglasii [1]	*hondurense*		
A. gillii [1]	*A. nigrum*		
A. laricis	*A. pendens*		
A. littorum	*A. rubrum* (includes *A. oaxacanum*)		
A. microcarpum subsp.	*A. strictum*		
aristatae	*A. vaginatum subsp.*		
microcarpum	*durangense*		
A. monticola	*vaginatum*		
A. occidentale	*A. verticilliflorum*		
A. pusillum	*A. yecorense*		
A. siskiyouense			
A. tsugense subsp.			
amabilae			
contortae			
mertensianae			
tsugense			
A. vaginatum subsp.			
cryptopodum [1]			

[1] – also occurs in Mexico; [2] – also occurs in the United States; [3] – also occurs in Asia.

Forthcoming Classification of *Arceuthobium* in the Flora of North America

Every forest pathologist, botanist, and forester who works with *Arceuthobium* in any capacity needs to be aware that Dan Nickrent has prepared a treatment of the mistletoe family Viscaceae for publication in one of the future volumes of the Flora of North America (FNA). In this treatment Dan is proposing a very different classification for *Arceuthobium* than that proposed by Hawksworth and Wiens. In the treatment I have read, Dan only recognizes seven species of *Arceuthobium* in the United States and four species in Canada. As mentioned above, Dan only recognizes species that are monophyletic based solely on his molecular data for nrDNA ITS and cpDNA *trnT-L-F* sequences, and therefore, he again grouped nearly all of the species recognized by Hawksworth and Wiens that are aligned with *A. campylopodum* under this taxon (Table 11). The only species he maintains in his treatment that might have also been "lumped" with *A. campylopodum* because of their morphological similarities to *A. campylopodum* were *A. blumeri* and *A. divaricatum*. However, for some reason Dan overlooked A. gillii and did not include it in the treatment I have reviewed. However, based on Dan's molecular findings I am confident he will recognize it as a separate species and not group it under *A. vaginatum*. It is interesting to note that while Dan did not recognize subspecies of *Arceuthobium* in his 2004 classification of *Arceuthobium*, he has maintained *A. vaginatum* subsp. *cryptopodum* (Southwestern dwarf mistletoe) in his treatment for FNA.

Table 11. Classification of *Arceuthobium* proposed by Dan Nickrent for the Flora of North America (FNA).

Recognized Species In FNA	Includes these species recognized by Hawksworth and Wiens
A. americanum	*A. americanum*
A. blumeri	*A. blumeri*
A. campylopodum	*A. abietinum; A. apachecum; A. californicum; A campylopodum; A. cyanocarpum; A. laricis; A. littorum; A. microcarpum; A. monticola; A. occidentale;, A. siskiyouense; A. tsugense.*
A. douglasii	*A. douglasii*
A. divaricatum	*A. divaricatum*
A. gillii [1]	*A gillii*
A. pusillum	*A. pusillum*
A. vaginatum subsp. *cryptopodum*	*A. vaginatum* subsp. *cryptopodum*

[1] – This species was not mentioned in the first draft of the treatment, but will probably be added to the final version of the proposed classification.

Please keep in mind that once Dan's FNA treatment of *Arceuthobium* is published in 2010 or 2011, it may gain acceptance by some scientists who are not as knowledgeable as forest pathologists regarding the Hawksworth and Wiens classification. Therefore, you will start seeing references made to *A. campylopodum* which are actually referring to very different dwarf mistletoe populations. Again, keep in mind that economically important dwarf mistletoes such as *A. abietinum*, *A. laricis*, and *A. tsugense* will all be considered as *A. campylopodum* under the FNA treatment. Using the key that accompanies the treatment of *Arceuthobium* in the FNA, most dwarf mistletoe populations in the western United States will be identified as *A. campylopodum*. Only *A. americanum*, *A. douglasii*, *A. pusillum*, and *A. vaginatum* subsp. *cryptopodum* will be relatively easy to identify using the FNA key and species descriptions.

It is interesting to compare the classification that Dan Nickrent is proposing for *Arceuthobium* based on his molecular data with that proposed by George Engelmann in the 1870s (about 140 years ago!) by comparing Tables 2 and 10. Dan Nickrent's classification is much more conservative in that many of the species that Engelmann recognized as being different based primarily on morphological differences, are all grouped under *A. campylopodum* based on the molecular evidence Dr. Nickrent has thus far. These include Engelmann's *A. abietinum*, *A. microcarpum*, and *A. occidentale*. Please remember that the FNA treatment proposed by Dr. Nickrent completely ignores 40 years of detailed field work by Hawksworth and Wiens, as well as the work of many other forest pathologists who have studied dwarf mistletoe in their natural environment for many years. I encourage all forest pathologists to continue to use the Hawksworth and Wiens system of classification for *Arceuthobium* and work diligently to educate other resource management professionals, botanists, etc. that they too should continue to follow the Hawksworth and Wiens system. This will continue to facilitate clear communication between professionals regarding specific dwarf mistletoe populations and will continue the use of a practical system of classification that applies to ecological, pathological, and economic aspects of dwarf mistletoe biology and management.

Final Comments Regarding the Classification of *Arceuthobium*

Typically, forest pathologists including myself, don't enjoy nomenclatural changes whether it is for fungi associated with important tree diseases or the dwarf mistletoes. Most forest pathologists and many foresters in general, are knowledgeable of the Hawksworth and Wiens classification for *Arceuthobium* and this is what they use whenever identifying, studying, or managing these parasitic flowering plants. Hawksworth and Wiens were the "modern architects" of the genus and their detailed work on this group of economically important pathogens is by far the most detailed and accurate information we have available regarding their classification. All of the current Forest Insect and Disease Leaflets for dwarf mistletoes follow the Hawksworth and Wiens classification.

Those of us continuing taxonomic work on *Arceuthobium* have learned that usually Hawksworth and Wiens "had it right," but occasionally they missed some minor details about the morphology or host preferences of specific populations that for a variety of reasons they did not have enough time to study in more detail. My efforts have attempted to identify some of those dwarf mistletoe populations, spend more time working on them than Hawksworth and Wiens could, and use many of the same techniques they used to "fine tune" the basic classification system they developed over 40 years of intensive field and laboratory studies. I am the first to admit that NONE of the new subspecies we have described or the new combinations we have published over the last 10 years modify the Hawksworth and Wiens classification to any large extent. They are only different interpretations of how to classify some specific dwarf mistletoe populations using additional morphological, phenological, host range, and to some extent molecular information that has become available since the Hawksworth and Wiens monograph was published in 1996 (compare Tables 3 and 11).

The new subspecies have been validly published with Latin diagnoses in peer-reviewed botanical journals and so they are available for use by anyone working with the specific dwarf mistletoe populations they address. As far as I am concerned, there are no completely tenable reasons or arguments why you should not continue to use the basic Hawksworth and Wiens 1996 classification for *Arceuthobium*. It is an outstanding achievement and deals with nearly all of the subtleties of most dwarf mistletoe populations in the United States. Some forest pathologists who deal with specific populations, such as those in northern CA and southern OR, may feel that more "lumping" for that region may be warranted. However, the new proposal for classifying almost all of the dwarf mistletoes in that area as *A. campylopodum* is going too far. Based on the data in Hawksworth and Wiens' 1996 monograph, many of the species grouped by Nickrent under *A. campylopodum* could have possibly been classified as subspecies of *A. campylopodum*. However, the FNA would require that Dr. Nickrent publish new combinations for any subspecies of *A. campylopodum* before they would print a treatment that recognized the proposed subspecific classification. Nickrent has no morphological, phenological, or host range data of his own on which to base a new classification of *A. campylopodum* using subspecies. At one time, Dr. Nickrent was going to designate the species recognized by Hawksworth and Wiens which he groups under *A. campylopodum* as forms (forma), but the FNA does not allow the use of designations below subspecies or variety, which includes forma. Hence, he has just "lumped" the 11 species listed in Table 11 with *A. campylopodum*.

Of course, as more information from morphological and molecular studies becomes available, eventually an entirely new classification for *Arceuthobium* may be proposed in 20-30 years? I can imagine that we will soon be able to sequence all of the DNA in the genome of every population of *Arceuthobium*, find out exactly what genetic/molecular mechanisms are responsible for the extreme host specificity some dwarf mistletoes exhibit, and link this to the genetics of the host populations as well. Maybe that research will suggest that there are many more species or subspecies of *Arceuthobium* than even I can imagine at this point. One thing I have learned about dwarf mistletoes, like every other pathosystem we forest pathologists study, is that there is always something new to learn about them.

With regards to shore pine dwarf mistletoe in British Columbia, I will continue to argue for and recommend that it is a more desirable alternative to treat it as a subspecies of *A. tsugense* than as a race (see Table 4). Maybe someday the genetic/molecular work on *A. tsugense* will suggest that all of the subspecies currently recognized should just be treated as strains or races of it, but for now the use of subspecies to designate slight morphological and host range differences among some dwarf mistletoe populations is the best system available. Even Hawksworth and Wiens believed that subspecies, not variety or forma, was the best taxonomic designation for acknowledging the small differences between some dwarf mistletoe populations that we can measure and/or observe. Even though they maintained that subspecies should be geographically isolated, they did not follow their own recommendation because some of their subspecies co-occur such as *A. vaginatum* subsp. *vaginatum* and subsp. *cryptopodum* in Chihuahua, Mexico and A. *tsugense* subsp. *tsugense* and subsp. *mertensianae* in Oregon.

Of course, I am hoping that the recognition of Wien's dwarf mistletoe will eventually be adopted by knowledgeable dwarf mistletoe experts because it commemorates the work of Del Wiens. Hawksworth's dwarf mistletoe is still recognized, be it as a subspecies or a species, so I thought it would be appropriate to have a dwarf mistletoe named in honor of Del Wiens also. The populations of *A. abietinum* in northwestern CA and southwestern Oregon that I have classified as subsp. *wiensii* should no longer be treated as *A. abietinum* f. sp. *concoloris* because they parasitize red fir. They are not f. sp. *magnificae* because they infect white fir as well. If investigators don't wish to recognize Wiens' dwarf mistletoe as a valid subspecies, they should not identify the dwarf mistletoe populations parasitizing Brewer spruce, white fir, AND red fir in northern CA as f. sp. *concoloris* for reasons just mentioned, they should just classify those populations as *A. abietinum*.

I plan to continue my efforts to "fine tune" the Hawksworth and Wiens classification system and this will probably lead to some more new combinations for some species as subspecies or more descriptions of new subspecies. But I will continue to follow the Hawksworth and Wiens basic classification for *Arceuthobium* and recommend that the new classification proposed by Dan Nickrent in the FNA not be adopted. I will not use the Nickrent classification in FNA and recommend that you don't use it as well. But you need to be aware that it is probably going to be published in the next year or two and may start being used by botanists and other scientists when referring to dwarf mistletoes in the United States and Canada. That would negatively affect communication regarding dwarf mistletoes, but as long as you can determine what the host and location of the dwarf mistletoe (s) an article is discussing, you should be able to determine which Hawksworth and Wiens species is being referred to as *A. campylopodum*. Sometime it will actually be *A. campylopodum*!

Unless we completely modify the current taxonomic nomenclatural system to only use molecular data as some taxonomists are advocating, the Hawksworth and Wiens system is still the best available classification for dwarf mistletoes. New species of *Arceuthobium* will be a rarity, but someone may discover a new species, but it will be found somewhere that Hawksworth and Wiens did not explore, such as China. Another possibility is that the populations of *A. oxycedri* in Europe and Asia will eventually be examined more closely and we will learn that there are indeed some cryptic differences between many of the populations of that widely distributed mistletoe. Of course, additional molecular work will probably be the primary source of new genetic information and may eventually reach a point where we are all convinced that the molecular evidence is so overwhelming and compelling that it should be weighted to the point that we do have to shift our species concept in *Arceuthobium* completely to a system that primarily uses molecular data as Dan Nickrent would like to do now. I don't think we will ever stop using morphological and physiological characters of organisms for their identification in the field, unless we develop portable DNA sequence devices that work like GPS units! Based on the many morphological and host affinity differences that exist for the species of *Arceuthobium* recognized by Hawksworth and Wiens, I don't predict that the Nickrent system will stand the test of time and it will eventually be found to have relied on undependable markers. Maybe not, but one thing I am certain of – we will continue to obtain new information related to the genetic differences between the organisms associated with tree diseases that will from time to time require all of us to stay informed about nomenclatural changes that are proposed based on the new information. I will always be in favor of a classification for *Arceuthobium* that considers all of the morphological, physiological, and genetic/molecular information available for developing both a phylogenetically representative as well as practical classification that forest pathologists can apply while performing their profession.

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Douglas-fir – *Phellinus sulphurascens* Pathosystem Research: an Overview

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Extended Abstract

Douglas-fir (DF, *Pseudotsuga menziesii* (Mirb.) Franco) is an economically and ecologically important species in the forests of western North America. Its dense wood is exceptionally hard, stiff and durable, making it outstanding for heavy-duty construction. DF is also a drought-tolerant species - an attribute that may see it favoured over other forest plant species (1) as North American and indeed all ecosystems are affected by the world's changing climate.

Investment in DF tree improvement programs started in the Pacific Northwest of the USA and British Columbia (BC) in the 1950s and early 1960s and continues today (2,3). Valuable seed and tissues sources developed through selection, breeding, and testing have been deployed in seed and clonal orchards to ultimately produce trees with increased wood volume and improved wood quality (3,4). To increase the likelihood that the gains they have made are not compromised by other factors, DF breeders have become increasingly interested in obtaining genomic-based information on DF responses and resistance to biotic and abiotic stressors (e.g., diseases, drought) (4).

Phellinus sulphurascens Pilát (syn. *P. weirii* (Murrill) Gilb.), a fungus native to North America, is a significant root pathogen affecting the survival and productivity of DF in western forests (5). The disease it causes, Laminated Root Rot, is considered to be a damaging agent of high priority by forest managers in both BC (6) and the western USA. *Phellinus sulphurascens* also impacts coniferous species in forested areas of northern Japan and in eastern China and Russia (7, 8).

Little is known about the genetics of *P. sulphurascens*, especially relative to which genes influence pathogenicity, diversity, and speciation.
Our pathosystem project objectives are to: 1) Identify and characterize genes responsible for DF resistance to *P. sulphurascens* and for DF response to *P. sulphurascens* infection and other stress agents; 2) Identify and characterize genes contributing to the pathogenicity of *P. sulphurascens*; 3) Provide genetic profiles and evolutionary history for world isolates of *P. sulphurascens*.

A summary of our pathosystem project accomplishments and publications to date are outlined below:

Techniques

- Developed a rapid technique(s) to differentiate *P. weirii* from *P. sulphurascens*

- Developed a molecular method that can be used to differentiate *P. sulphurascens* homokaryons from *P. sulphurascens* heterokaryons.

- Developed an *in vitro* inoculation methodology to study aspects of the *P. sulphurascens*-Douglas-fir pathosystem.

- Developed method to induce formation of *P. sulphurascens* sporophores; fruit bodies yield single spore isolates, which are critical to genetic and population studies of the fungus.

In: Adams, J. comp. 2010. Proceedings of the 57th Western International Forest Disease Work Conference; 2009 July 20-24; Durango, CO. Forest Health Technology Enterprise Team Ft Collins, CO
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Identification of important DF genes & Understanding of the DF - *P. sulphurascens* interaction

- Conducted first-ever scanning & transmission electron microscopic and immunohistochemical investigations of *P. sulphurascens*-infected DF root tissues to better understand this interaction.

- Created a cDNA library from *P. sulphurascens*-infected DF seedling roots and from this library have identified a large number of plant defense related genes and proteins involved in DF response to infection.

- Using real-time PCR and a range of DF families (including those identified to have differential resistance to *P. sulphurascens*), have initiated studies to identify which of these genes may play a role in DF resistance to the fungus (= ID of markers for resistance).

Identification of important fungal pathogenicity genes and knowledge of pathogen diversity

- Have established a unique collection of *P. sulphurascens* and *P. weirii* isolates from western North America and Asia; isolates currently total 200.

- Created a cDNA library from 'induced' *P. sulphurascens* mycelia and from this library have identified a large number of pathogenicity-related proteins and genes involved in the infection biology of the fungus.

- Using real-time PCR and a range of *P. sulphurascens* isolates (including two isolates we demonstrated to vary in virulence and aggressiveness), have initiated studies to identify which of these genes play a role in the pathogenicity of this fungus (= ID of pathogenicity markers).

Some of our publications (all available at the CFS Bookstore, http://bookstore.cfs.nrcan.gc.ca/home_e.php)

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Committee Reports

“Climate Change Committee Report”
Committee Co-chairs:
Charles G. "Terry" Shaw, David Shaw and Susan J. Frankel

“Dwarf Mistletoe Committee Report”
Chair: Fred Baker

“Foliar and Twig Disease Committee Report”
Acting Chair: Bill Jacobi

“Hazard Tree Committee Report”
Acting Chair: Mary Lou Fairweather

“Nursery Pathology Committee Report”
Chair: Katy Mallams

“Root Disease Committee Report”
Acting Chair: Mike Cruickshank

“Rust Committee Report”
Chair: Holly Kearns

Climate Change Committee Report

Committee Co-chairs:
Charles G. "Terry" Shaw, David Shaw and Susan J. Frankel

Approximately 40 people attended the 2009 WIFDWC Climate Change Committee meeting.

Koren Nydick, Executive Director of the Mountain Studies Institute, http://www.moutainstudies.org/ presented her collaborative, climate change research, (with the Consortium for Integrated Climate Research in Western Mountains (CIRMOUNT) http://www.fs.fed.us/psw/cirmount/ and others), highlighting their children's outreach program and work in fens. She extended a rallying cry to pathologists to get involved in climate change research and management since forest pathology expertise is need to understand forest disturbance.

James Worrall, USFS, Forest Health Protection, Gunnison Office presented a short overview of alder decline in the Rocky Mountains predicting increased damage from Cytospora cankers and other problems for alder if the climate becomes hotter and drier. More work is needed to fully understand all the factors driving the decline of alder.

Bill Jacobi and **Betsy Goodson**, Colorado State University are writing an Aspen risk assessment with funding from the Western Wildland Environmental Threat Assessment Center (WWETAC) www.fs.fed.us/wwetac/index.html.

Eric Smith, USFS, Forest Health Technology Enterprise Team, www.fs.fed.us/foresthealth/ technology/index. shtml, explained efforts to incorporate climate change's influence into the Forest Health Protection, National Pest Risk Map.

Mee-Sook Kim and **Ned Klopfenstein** described their new publication:
Klopfenstein, Ned B.; Kim, Mee-Sook; Hanna, John W.; Richardson, Bryce A.; Lundquist, John E. 2009. Approaches to predicting potential impacts of climate change on forest disease: an example with Armillaria root disease. Res. Pap. RMRS-RP-76. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 10 p. http://www.fs.fed.us/rm/pubs/rmrs_rp076.pdf.

Abstract
Predicting climate change influences on forest diseases will foster forest management practices that minimize adverse impacts of diseases. Precise locations of accurately identified pathogens and hosts must be documented and spatially referenced to determine which climatic factors influence species distribution. With this information, bioclimatic models can predict the occurrence and distribution of suitable climate space for host and pathogen species under projected climate scenarios. Predictive capacity is extremely limited for forest pathogens because distribution data are usually lacking. Using Armillaria root disease as an example, predictive approaches using available data are presented.

The following general climate change resources were recommended:

1) Website of the United States Global Change Research Program http://www.globalchange.gov/
2) Baron, Jill S.; Julius, Susan Herrod; West, Jordan M.; Joyce, Linda A.; Blate, Geoffrey; Peterson, Charles H.; Palmer, Margaret; Keller, Brian D.; Kareiva, Peter; Scott, J. Michael; Griffith, Brad 2008. Some guidelines for helping natural resources adapt to climate change. IHDP Update. 2:46-52. http://www.fs.fed.us/psw/cirmount/publications/pdf/IHDP2008_Baron_etal.pdf

Susan J. Frankel

Dwarf Mistletoe Committee Report
Chair: Fred Baker

We met Friday morning with approximately 20 people, although a few more filtered in. Fred Baker mentioned the results of a study evaluating mistletoe incidence on FIA plots in black spruce. FIA missclassified dwarf mistletoe status in 20% of the stands, with errors of omission being twice as likely as errors of commission. The Minnesota Department of Natural Resources inventory detected mistletoe in 23% of infested stands. This study will be submitted to the Northern journal of Applied Forestry. Using stand characteristic data from our survey, we have developed a statistical model to enhance the accuracy of the state's dwarf mistletoe assessment. This model suggests that 25% of Minnesota's black spruce stands are infested. This paper will soon go to Ecological Modelling.

Oscar Dooling's 38 year-old Douglas-fir dwarf mistletoe plots were measured in 2008. The study was designed to help determine levels of dwarf-mistletoe removal through thinning and pruning that would reduce wood volume losses below an economic threshold and help understand the spread and intensification of Douglas-fir dwarf mistletoe in thinned stands. The Forest Vegetation Simulator (FVS) over-predicted both spread and intensification of Douglas-fir dwarf mistletoe in almost all instances. Forest Health Protection Numbered Report 08-08 (Douglas-fir Dwarf Mistletoe Spread, Intensification, and Tree Growth Impact: Thirty-Eight Year Remeasurement) can be found at: fs.fed.us/r1-4/spf/fhp/publications/bystate/R1Pub08-09_DFMistletoe_treegrowthimpact.pdf

In addition, Dooling established a very similar study for lodgepole pine dwarf mistletoe in 1971. This study was more fully implemented than the Douglas-fir dwarf mistletoe study mentioned above. Sixteen of the original 36 lodgepole pine plots were remeasured during the summer of 2009, with regeneration subplots added. These plots represent four replicates of three thinning treatments and a control. They may be of particular interest to FVS model users since the FVS Dwarf Mistletoe Impact Modeling (DMIM) System users' guide (2005) states the model's spread and intensification "is based on a study of 1,200 lodgepole pine in Gallatin National Forest in Montana" (pg. 10). The 1,200 trees mentioned are from this study. A report with comparisons of true data to FVS projections should be completed early 2010.

Marcus Jackson, Forest Health Protection, USDA Forest Service, Northern Region. Bob Mathiesen mentioned that there is a mistletoe on red and white fir and Brewer Spruce and named it *A. abietinum* subsp *weinsii*. Paper will be out next August or September in Madrono. He also indicated that he is reviewing Dan Nickrent's revision of *Arceuthobium* taxonomy for the Flora of North America. Based on genetic evidence (ITS sequence) he recognizes only 7 species in North America. *A. campylopodum* will include hemlock and fir dwarf mistletoes, and too many others to be useful. Enthused discussion followed. Bob will draft a letter to the editor of Flora of North America summarizing our views that such a taxonomy is premature and will not be used by our group and foresters. The letter will be posted to this group, and, after sufficient edits, it will be forwarded to our chair for signature. He also mentioned a Plant Disease mistletoe article by Mathiasen, Dave Shaw, Dan Nickrent and others. Reprints are available from any of the authors.
(Letter to Flora of North America Follows)


Fred Baker

Dr. David E. Boufford
Harvard University Herbaria - 22 Divinity Avenue - Cambridge, MA 02138

September 11, 2009

Dear Dr. Boufford:
The Western International Forest Disease Work Conference (WIFDWC) represents forest pathologists from all over the World, but its membership is primarily comprised of pathologists from the United States, Canada, and Mexico. The Conference's annual meetings provide forest pathologists a venue for discussing new findings and important issues related to tree diseases, primarily but not limited, to forests in western North America. Members of WIFDWC are practicing forest pathologists from federal and state resource management agencies, academia, and professional foresters representing private and industrial landowners and state and federal agencies. In this capacity, WIFDWC represents most of the forest pathologists in the western United States and Canada.

We recently became aware that Dr. Dan Nickrent is proposing a drastically different classification system for both *Arceuthobium* and *Phoradendron* for his treatment of the Viscaceae in the Flora of North America. Since you are the FNA Editor handling Dr. Nickrent's treatment, we are addressing our concerns to you. Based primarily on molecular evidence, Nickrent is greatly reducing the number of species in *Arceuthobium*. Several of the most economically and ecologically important species of *Arceuthobium* occurring in the western United States and Canada will be grouped into a single species. These include *A. abietinum* which parasitizes true firs, *A. californicum* on sugar pine, *A. laricis* which affects western larch, and *A. tsugense* which is a damaging parasite of hemlocks. These dwarf mistletoes are morphologically distinct, have extremely different host ranges, and when they occur together they stay on their primary host. There is no evidence of hybridization. Even to a forest manager, *A. tsugense* is different from *A. laricis*; grouping them as one species makes no sense to those who work with these mistletoes for wildlife habitat or to mitigate the damaging effects of mistletoe on the growth and longevity of economically important conifers.

Dr. Nickrent has evidently based his proposed treatment almost entirely on his molecular data. He has chosen to disregard copious data on the morphology, phenology, and host affinities of the dwarf mistletoes listed above. His treatment will not only confound the vast amount of literature on biology and management, but it will also make our efforts to control their negative impacts more difficult.

Dr. Nickrent has also chosen to follow Dr. Job Kuijt's 2003 monograph for *Phoradendron*. Dr. Kuijt has also grouped several distinctive species of *Phoradendron* with different morphological characteristics and host preferences, which makes this taxonomy impractical for use. In addition to clarifying phylogeny, a classification system should provide a practical and reasonable approach which facilitates the identification and management of mistletoes; a system that fails in these tasks will not be used by forest pathologists and foresters, as evidenced by the lack of acceptance of Kuijt's taxonomy. Our objections to both of these taxonomies are not based on resistance to change; using molecular data alone ignores morphological, phenological, and biological information about these taxa that are an important basis for identification, management and research. ITS sequences apparently do not capture all of the variation in these groups.

The classification of mistletoes and fungi associated with tree diseases is critical to our professions ability to communicate among ourselves, with other resource management professionals, and in our research efforts. A useful taxonomy should recognize important biological differences that are essential for successful management of these important pathogens; Dr. Nickrent's taxonomy will not. The proposed taxonomy will confound the massive literature on this group. Dr. Nickrent's treatment of the Viscaceae will result in much confusion among individuals attempting to use it and therefore, it, like the taxonomy proposed in his 2004 paper, will simply not be used. Because our members educate most of the professional foresters in the western United States and Canada at universities or by providing in-service training sessions on forest diseases and insects, FNA with Nickrent's proposed treatment will not be used.

We encourage you to work towards the publication of a classification system for *Arceuthobium* and *Phoradendron* in the Flora that our members will find practical and useful. We ask you to encourage Dr. Nickrent to look beyond the molecular evidence and incorporate the consistent morphological, phenological and host preference data into his treatment. We ask you to convey to him the importance of this taxonomic work to the practitioner. If the treatment is published as it now stands it will not be promoted or used by forest pathologists or foresters in the western United States and Canada. Thank you for your consideration of this important topic.

Sincerely,

Dr. Gregory M. Filip
Chair, Western International
Forest Disease Work Conference (WIFDWC)
Forest Health Protection, USDA Forest Service
P.O. Box 3623, Portland, OR 97208
gmfilip@fs.fed.us

Dr. Fred A. Baker
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Foliar and Twig Disease Committee Report
Acting Chair: Bill Jacobi

The committee meeting was attended by 18 members and all those in attendance were in favour of asking for permanent committee status.

Short Reports were presented by:

Dave Shaw – An update on the Swiss Needle Cast Coop in Oregon.

Brent Oblinger – University of Wisconsin-Madison Diplodia shoot blight as a threat to artificial red pine regeneration efforts on clearcut sites.

Katy Marshall - Jeff Stone, Department of Botany and Plant Pathology, Oregon State University, and Danielle Martin, graduate student, recently completed an FHP Special Technology Development Project, <u>Developing Techniques for Evaluating the Susceptibility of Root Disease-resistant Port-Orford-cedar to Foliar and Stem Canker Diseases</u>. They used field trials and artificial inoculations to study susceptibility of seedlings with varying levels of resistance to Port-Orford-cedar root disease to cypress canker (caused by *Seiridium* spp.) and Stigmina foliage blight (caused by *Stigmina thujina*). There were significant differences in susceptibility to both pathogens in artificial inoculation trials among the thirty families of seedlings tested. However, there was no significant correlation between susceptibility to root disease and susceptibility to either cypress canker or Stigmina foliage blight.

They also surveyed Port-Orford-cedars in a common garden study naturally infected with *Stigmina*. Trees from families that originated in the southernmost, more inland provenances, at higher elevations and drier sites had the most severe disease symptoms.

Seiridium isolates collected in southern Oregon for the study were morphologically similar to *S. cardinale.* However, phylogenetic analysis grouped them in a sister relationship with *S. unicorne* isolates from Portugal. It suggests that there may be greater variation in morphological characteristics of *S. unicorne*, or that the *Seiridium* species in Oregon represents a hitherto unrecognized species.

Jim Blodgett – reported on extensive Diplodia events in ponderosa pine after hail events in the Black Hills.

Willis Littke – reported on the problems arising from the upcoming ban on Bayleton for fusiform rust protection in southern nurseries. Also reported on a student's work at University of Florida to develop a Rapid Diagnostic Test for Pitch Canker using PCR.

Hazard Tree Committee Report
Acting Chair: Mary Lou Fairweather

Approximately 25 people attended the WIFDWC Hazard Tree Committee Breakfast. Four items were on the formal agenda:

1) Bruce Moltzan led a discussion on a number of items.

- Thanked those that commented on revisions to the Forest Service Handbook, FSH 7709.59 – Road system operations and maintenance handbook, Chapter 40 – Highway safety program, that John Bell drafted before his retirement. This revision reiterated how complicated hazard tree detection programs can be.
- A National Hazard Tree plan will be drafted in 2010.
- A hazard tree survey will be drafted soon aimed at collecting information from FHP directors.
- Will explore concessionaire contract language to see how newer contracts handle responsibilities for identifying and mitigating hazard trees.
- There was a group discussion on lack of funding at the District level for hazard tree identification and mitigation in developed sites.
- Marcus Jackson described their regions pursuit of offering vegetation management process for developed sites.

2) Greg Filip discussed plans for the next Hazard Tree Workshop. The workshop will be held June 14-17, 2010, in Medford, Oregon. An agenda has already been drafted and includes one and one-half days in the field. The Region 6 Danger Tree Program will be featured during this workshop.

3) Judy Adams next led a discussion on the International Hazard Tree Failure Database (ITFD). Mark Duntemann, an urban forestry consultant, now chairs the ITFD Steering Committee. There is a continuing need to encourage greater use of and data input into the ITFD, as it is difficult to do data analysis without more data in the system. Efforts are underway to get the forms into a database that would allow information to be entered from the field.

4) Mary Lou Fairweather updated everyone on the status of the nine decay FIDLs that are currently being updated. Three have already been completed: FIDL 149 - Decay and Discoloration of Aspen; FIDL 150 - Decays of Engelmann Spruce and Subalpine Fir in the Rocky Mountains; FIDL 93 – Rust Red Stringy Rot. A couple are almost ready for review and a few are unknown.

The group then discussed Matteo Garbelotto's wooddecay.org website and DNA-testing procedures for detecting species of wood decay fungi in failed trees. Jesse Micales Glaeser explained the basic process to the group. The techniques behind this DNA-based test are evolving and caution is advised in using the results.

We ran out of time for any round robin item.

Nursery Pathology Committee Report
Chair: Katy Mallams

The WIFDWC Nursery Pathology Committee met on Monday afternoon, July 20th. Eight people attended. Highlights of the discussion included:

In 2008, the Committee began a discussion about revising FIDL 157, Nursery Diseases of Western Conifers. Discussion continued after the meeting via e-mail, and it was ultimately decided that updating Agriculture Handbook 680, Forest Nursery Pests would be more useful. Region Six FHP has agreed to fund editing and printing. The revised Handbook will also be made available on-line in PDF format. Katy Mallams (R-6 FHP), Michelle Cram (R-8 FHP) and Kas Dumroese (National Nursery Specialist, RMRS) are coordinating the project. The group discussed topics that should be included in the updated Handbook and potential chapter authors.

Ned Klopfenstein reported that the Rocky Mountain Research Station has Bob James' extensive collection of *Fusarium* cultures. However, they have no money to maintain the collection. They would like to see it taken care of, but would also like researchers to have access to the cultures. A suggestion was made to contact the Fusarium Research Center at Pennsylvania State University.

Nursery-related work reported by committee members:

Jim Blodgett (R-2 FHP): susceptibility of conifer seedlings grown in R-2 nurseries to Diplodia blight

Anna Leon (graduate student, U. of Washington): research on alternatives to methyl bromide

Mee-Sook Kim (RMRS and Kookmin University, Seoul, Korea): pathogenicity and distribution of *Fusarium commune* in the western U.S.

Brent Oblinger (graduate student, U. of Wisconsin): slash as a source of *Diplodia* inoculum affecting reforestation in forest plantations

Will Littke (Weyerhaeuser): fumigation issues at southern nurseries.
He also reported on:

- Work on *Pythium* species in nursery soils and relation to outplanting mortality by John Browning (Weyerhaeuser)
- A rapid diagnostic test for pitch canker being developed by Tyler Dreaden and Ed Barnard at U. of Florida
- Development of a highly efficient machine for applying fumigants by ARS in Florida.

Katy Mallams

Root Disease Committee Report
Acting Chair: Mike Cruickshank

This year's meeting did not have a central theme but was instead utilized for a round-robin sharing and discussion regarding ongoing projects, research results, collaborative needs, etc. Following are brief summaries:

Jim Blodgett (U.S. Forest Service, Forest Health Protection): The species-identification crosses were completed in winter 2008/2009 for the "Distribution, species, and ecology of *Armillaria* fungi in Wyoming" study. The four species found in Wyoming include *A. ostoyae* (the most common), followed by *A. sinapina*, *A. gallica*, and *A. cepistipes*.

Mike Cruickshank (Canadian Forest Service, Canadian Wood Fibre Centre): I am working on impacts, both growth loss and longer term mortality rates, used for risk analysis. I am also monitoring a long-term stumping trial for Armillaria root disease and hope to publish soon on the 40-year results. I am starting work on Armillaria and wood quality as it relates to logs, lumber, and pulp.

Jessie Glaeser (U.S. Forest Service, Northern Research Station): The P- and S-type intersterility groups of *Heterobasidion* from North America are being given species status in the following publication:
Otrosina, W.J., and Garbelotto, M. 2009. *Heterobasidion occidentalis* sp. nov. and *Heterobasidion irregularis* comb. nov.: A disposition of North American *Heterobasidion* biological species. Mycological Research (in press).

The P-type intersterility group should now be called *Heterobasidion irregularis*, and the S-type group referred to as *Heterobasidion occidentalis*. This completes the separation of the *H. annosum* species complex into five major species, three of which are in Europe. *Heterobasidion annosum* s.s. should only be used to refer to the "P-type" intersterility group from Europe, which is typically associated with pines. "Annosum root rot" or the older "annosus root rot" should now be referred to as "Heterobasidion root rot" (HRR).

Heterobasidion root rot is becoming a serious disease of native red pine (*Pinus resinosa*), an important commercial and plantation species in the Midwest. Very little is known about the disease in the East and the Midwest, including its distribution, how it spreads, how it infects other trees, and which management strategies would be effective for control. Wisconsin is a particularly interesting geographic area for HRR development since the state includes the extreme edge of the red pine range and contains the transitional zone between forest and prairie. Trees in such transitional zones may be more susceptible to climate change-induced stress since they are not growing under ideal conditions.

A project has been developed that will 1) develop DNA-based detection tools that can be used by USFS Forest Health Protection and state personnel to inventory HRR incidence, and 2) to determine how the fungus spreads to uninfected stands. The development of *Heterobasidion*-specific primers paired with high through-put collection techniques will allow the processing of hundreds of field samples rapidly and inexpensively. This effort is needed to assess the current range of the pathogen and to differentiate infected from non-infected stands. In order to determine how the pathogen is spread, freshly cut pine disks will be distributed in close proximity to trees with sporulating conks. The trap disks will be removed and replaced bi-weekly and examined for the growth and sporulation of the asexual, rapidly growing stage of the fungus. Quantitative relationships between spore deposition and climatic factors, including temperature and wind, will be determined. In order for these research results to be useful, a science-based risk analysis system and associated management guidelines for HRR in the conifer-growing parts of the Midwest will be developed that will 1) prevent new introductions of the pathogen in conifer plantations, and 2) reduce the impact and further spread of the pathogen in stands in which it has already been established. Effective management strategies have been developed in Europe and the southern and western United States and could be adapted to Eastern and Midwestern forests once disease parameters are established.

Holly Kearns (U.S. Forest Service, Forest Health Protection): Currently serving as a member of the risk-map modeling team representing U.S. Forest Service Regions 1-4; Helen Maffei is representing Regions 5-6 and 10. Feel free to contact your respective Regional representative for any questions or input you may have on the risk map.

Walt Thies (U.S. Forest Service, Pacific Northwest Research Station - retired): All my research plots still exist but no one is assigned to measure them. There should, however, be a job advertisement out in the near future for a USFS-PNW Research Pathologist.

U.S. Forest Service Rocky Mountain Research Station:
The Rocky Mountain Research Station in Moscow (Ned Klopfenstein, John Hanna, and Amy Ross-Davis) and research collaborator Mee-Sook Kim (Kookmin University, Seoul, South Korea) are continuing DNA-based analyses of *Armillaria* spp. Ongoing work with Region 6 Forest Health Protection (Helen Maffei and Aaron Smith) includes sampling for the presence of *Armillaria* spp. in random plots across the East Cascades of Oregon, and identifying pathogenic species based on DNA diagnostics. This work will identify environmental factors that affect the distribution of pathogenic *Armillaria* spp. This knowledge will facilitate the refinement of multi-scale risk models for current and future climate scenarios.

Collaborations from other regions are being sought to expand these prediction models. International collaborations are also underway to examine genetic relationships among *Armillaria solidipes* (= *A. ostoyae*) and related species across the Northern Hemisphere. These studies will examine evolutionary relationships among isolates from diverse geographic regions, and will assess potential invasive species risks associated with pathogen movement.

Recent publications include:
Klopfenstein, N.B., Lundquist, J.E., Hanna, J.W., Kim, M.-S., and McDonald, G.I. 2009. First report of *Armillaria sinapina*, a cause of Armillaria root disease, associated with a variety of tree hosts on sites with diverse climates in Alaska. Plant Disease 93: 111.

Klopfenstein, N.B., Kim, M.-S., Hanna, J.W., Richardson, B.A., and Lundquist, J.W. 2009. Approaches to predicting potential impacts of climate change on forest disease: an example with Armillaria root disease. Research Paper RMRS-RP-76. USDA Forest Service, Rocky Mountain Research Station, Fort Collins, Colorado. 10 p.

Rust Committee Report
Chair: Holly Kearns

The Rust Committee meeting on the afternoon of July 20, 2009 was well attended. An extended meeting allowed for two formal presentations in addition to individual reports on current and upcoming rust-related projects. The following abstract, reports, and work summaries were submitted for inclusion in the Committee Report.

Anna Schoettle Resistance to white pine blister rust in *Pinus flexilis* and *Pinus aristata* of the Southern Rockies – initial findings Schoettle Anna W.[1]; Sniezko, Richard A.[2]; Kegley, Angelia[2]; Hill, Jerry[2], and Burns, Kelly S.[3] ([1] USDA Forest Service, Rocky Mountain Research Station, Fort Collins, CO; [2] USDA Forest Service, Dorena Genetic Resources Center, Cottage Grove, OR; [3] USDA Forest Service, Forest Health Management, Lakewood, CO; Corresponding author: aschoettle@fs.fed.us).

The non-native fungus *Cronartium ribicola*, that causes white pine blister rust (WPBR), is impacting or threatening limber pine, *Pinus flexilis*, and Rocky Mountain bristlecone pine, *Pinus aristata.* In the Southern Rockies, where the rust invasion is still expanding, we have the opportunity to be proactive and prepare the landscape for invasion. Genetic resistance to WPBR is essential to the future of pine populations given the lethality of the disease and its continued spread. Options for increasing the frequency of resistance in a stand includes (1) supplementing resistance by outplanting rust resistant stock and (2) stimulating natural regeneration to increase the numbers of individuals and genetic combinations for rust resistance selection (see Schoettle and Sniezko 2007).
Past studies have shown that resistance exists in both limber and RM bristlecone pine but did not address the genetic basis of resistance or its geographic distribution. We currently have six artificial inoculation rust screening studies examining complete and partial resistance traits for limber pine and RM bristlecone pine. Complete resistance to WPBR in limber pine has been evaluated in progeny of 113 limber pine seedtrees from 13 sites across the Southern Rockies and varies among sites from a frequency of 1 to 29% and demonstrated Mendelian segregation within some families suggesting that it is controlled by a single dominant gene (Schoettle, Sniezko, and Burns, unpublished data). Assessment of the frequency of the partial resistance mechanisms in limber pine is underway (Schoettle, Sniezko, Pineda-Bovin and Burns, in process). The frequency of partial rust resistance in progeny from 184 RM bristlecone pine seedtrees from 11 sites in Colorado varies among sites from a frequency of 17 to 60% (Schoettle, Sniezko, Kegley, and Burns, in progress) and varied among families.

These initial findings confirm that rust resistance is present in limber pine and RM bristlecone pine and has a genetic basis. The mechanisms of resistance are still unclear and field plantings are required to verify the expression and durability of the resistance traits in native habitats. The geographic variation in rust resistance in both species support the hypothesis that rust resistance is not independent of other adaptive traits or evolutionary legacies. As a result, identifying appropriate resistant stock for outplanting in populations with low frequencies of resistance may be challenging. Alternatively, stimulating natural regeneration to accelerate selection for rust resistance is only a viable option in those populations with higher frequencies of resistance. Additional research is needed to address the expression and durability of these mechanisms in a changing climate.

Other activities include:

To examine the ecological efficacy and economic trade-offs of management options for mitigating WPBR impacts in high elevation white pines, projections from population and epidemiology modeling are being integrated into a dynamic economic model. The research team includes Craig Bond (PI - CSU), Patty Champ (RMRS), Anna Schoettle (RMRS), Bill Jacobi (CSU), Cara Nelson (U MT) and Richard Sniezko (DGRC).

Maintaining a broad genetic base within and among populations is also essential for sustainability into the future in the presence of WPBR, mountain pine beetle and climate change. *Ex situ* gene conservation collections of seeds, leaf material and pollen for RM bristlecone and limber pine are ongoing. To date Schoettle and colleagues have archived genetic material from over 350 RM bristlecone and 500 limber pine individuals over 30 and 45 populations, respectively. With funding in 2009 from RMRS and the FHP Gene Conservation Program and collaborations with the R1 and R2 Forest Health Protection, National Park Service, Bureau of Land Management, National Forest Systems, Mountain Studies Institute and Colorado State University, limber pine collection sites now extend from Colorado to Montana. *In situ* conservation is underway, in the Southern Rockies, with protection from mountain pine beetle of high value trees and rust resistant populations of both limber pine and RM bristlecone pine using chemical and pheromone approaches.

Dave Conklin

Blister rust arrived in southern New Mexico by the early 1970s, and has more recently appeared in other several other locations in the Southwest. *Pinus strobiformis* is experiencing major damage on high hazard sites in the Sacramento Mountains (our original outbreak area), although lower hazard sites there are much less affected. We can expect a major expansion of the disease in the next few decades. Low hazard sites will provide important "genetic refugia" for white pines. A recent report, *White Pines, Blister Rust and Management in the Southwest*, quantifies our white pine resource, discusses our work with genetic resistance, and makes recommendations for favoring (retaining) white pines in all harvest and thinning operations.

Mary Lou Fairweather

After decades of looking, white pine blister rust was observed in Arizona for the first time in May 2009. Southwestern white pines are infected in high hazard areas (e.g. along canyon bottoms and creeks) in eastern Arizona, on the White Mountain Apache Reservation and adjacent Apache National Forest. The infected area encompasses approximately 40 square miles.

Marcus Jackson

Impacts from white pine blister rust, mountain pine beetle, and Dothistroma needle disease have spurred the need for an assessment of limber pine in Montana. This assessment is drawing on historical information and data collected in the state to describe current understanding of the amount, distribution, and condition of limber pine in Montana. In addition to data collected from sixteen Evaluation Monitoring (Forest Health Monitoring) plots, data collected by the United State Geological Survey, US Forest Service Forest Inventory and Analysis program, and the MT DNRC will be used in addition to publications identified through the Whitebark and Limber Pine Information System database. This information will be compiled and analyzed to produce an assessment in early 2010.

Bill Jacobi

Pruning studies at Sand Dunes National Park and Vedauwoo Campground on the Medicine Bow NF are doing well. We have not lost any trees to treatment but have lost about 10% of the trees at Vedauwoo to a mountain pine beetle outbreak. We have also started a project to determine how to plant limber pine seedlings by testing the impact of amount of crown closure, nurse objects and hydrogels.

Robin Mulvey

As a MS Candidate at Oregon State University, Robin is studying the role played by species of *Castilleja* and *Pedicularis* in whitebark pine ecosystems of the Cascade Range and determining if there is sufficient time for *C. ribicola* to complete its lifecycle in high-elevation whitebark pine ecosystems.

Dave Russell

CASSO-BLM-WPBR/Sugar Pine

- Produced 18,000 cones in 7 breeding units.
- Working with Dorena on F2 (best resistance) family list….to move seed orchard to Tyrrell and Horning SO.
- Currently growing @ 5,000 Sugar pine rootstock in containers at CASSO greenhouse for bench grafting families generated from above said list this December. Obtaining @ 7 MGR parents from R6.
- Submitting chosen SP family vegetative material to NFGEL/PSW/V. Hipkins in order to verify/validate family genetic identity.
- Received NFGEL Sugar Pine pollination contamination report from NFGEL this fall.
- Observing continued mortality due to *Phytophthora cryptogea @ 6% a year.*

Dave Shaw

Bear are peeling bark on pruned western white pine. So there is concern about pruning… more research is needed. I'm involved in a project with FHP and the Willamette National Forest looking at traditional pruning and long staub pruning and consequent bear damage.

Kelly Burns

In cooperation with Blodgett, Jacobi, Schoettle, and Sniezko: Recent research has shown that limber pines and bristlecone pines on several sites in northern CO and southern WY possess traits that offer resistance to *Cronartium ribicola* (Schoettle, Sniezko and Burns, in prep). In the northern Rockies, limber pine is heavily impacted by WPBR and populations in the southern Rockies are becoming infected as the disease continues to spread through Colorado. The disease has been shown to be present in krummholz of whitebark pine (Tomback, personal communication) so there is no reason to expect that the high elevation 5-needle pine forests in the Rocky Mountain Region will escape the disease. These studies (Schoettle, Sniezko and Burns, in prep) are the first to examine resistance of limber and bristlecone pine to WPBR within family structures. It is likely that with further sampling at these sites more resistant trees will be identified in the populations.

A mountain pine beetle (MPB) epidemic is occurring in northern CO and southern WY and unfortunately white pines are particularly suitable hosts. Beetle activity is increasing at several of these important sites and MPB poses an immediate threat to limber and bristlecone pine research trees in the area. The seedtrees whose progeny display resistance need to be protected from MPB until their genetic diversity is conserved and this may take several years. Since other non-tested trees within the population likely also have resistance, the population as whole should be protected from MPB as it offers invaluable continued research opportunities that will support management to mitigate impacts from WPBR into the future.

Plus trees and surrounding populations were treated with verbenone or carbaryl in the spring to reduce MPB attacks and each site was revisited in the fall to collect cones from each of the trees bearing viable cones. A bulk collection was also taken from additional trees at each site. Cone production was adequate at some sites but other sites were void of cones or cones were damaged by cone and seed insects. Seed trees will need to be treated yearly until the gene pool has been adequately conserved or until the threat of MPB impacts decreases. The goal of this program is to obtain at least 20 to 40 viable cones from each seed tree and a bulk collection composed of 2 to 4 cones from 20 trees on the site. We also plan on collecting scion from these sites.

In addition to collecting from genetically resistant trees we also collaborated with Rocky Mountain National Park, R2 National Forests (Pike-San Isabel NF, Arapaho-Roosevelt NF, Medicine Bow NF, Shoshone NF, Bighorn NF), Boulder County, and the BLM to identify, monument, and collect cones from putatively resistant limber pines throughout the Rocky Mountain Region. We would like to extend this effort throughout the range of limber pine in the future.

Kristen Chadwick

In Oregon and Washington, 62 permanent plots were established in 2009 in whitebark pine stands. Data collection methods focused on blister rust severity, mountain pine beetle activity, frequency of regeneration, as well as the density and condition of other species on the plot. This winter we will start working on a database to house our data and then populate WLIS and the Whitebark Pine Ecosystem Foundation Database.

Ned Klopfenstein

Report from USDA Forest Service Rocky Mountain Research Station - Moscow, ID:

Collaborative work is ongoing to examine genetic diversity of ohia rust or guava rust (*Puccinia psidii*), an invasive pathogen that is threatening native trees of the Myrtaceae family in Hawaii. Scientists from USDA Forest Service FHP Region 5 (Phil Cannon); University of Hawaii (Janice Uchida), Universidada Federal de Vicosa, Brazil (Rodrigo Neves Graca and Acelina Alfenas); Kookmin University, Seoul, South Korea (Mee-Sook Kim); Washington State University (Tobin Peever); and USDA Forest Service-RMRS, Moscow (Ned Klopfenstein) will examine the genetic diversity of the rust in Hawaii and in Brazil, where the rust is native. This work will help determine potential risks associated with future introductions of additional rust strains. Because *Puccinia psidii* can infect eucalypts, it is considered a critical invasive pathogen of worldwide importance. In other collaborative work, several forest pathologists formulated a response plan to address potential threats posed by the introduction of Scot's pine blister rust (*Cronartium flaccidum*).

Collaborative studies are underway to examine the genetic relationships among white-pine-blister-rust pathogens (*Cronartium ribicola*) from diverse geographic sources across Eurasia and North America. Preliminary results indicate that the blister rust in North America did not originate from the areas sampled in Japan, Korea, or China. Work will continue in search of the evolutionary origin of *C. ribicola*. Other studies are examining the range-wide population structure of western white pine (*Pinus monticola*). Recent publications include: 1) Richardson, B.A., Zambino, P.J., Klopfenstein, N.B., McDonald, G.I., and Carris, L.M. 2007. Assessing host specialization among aecial and telia hosts of the white pine blister rust fungus, *Cronartium ribicola*. Canadian Journal of Botany 85: 299-306; 2) Richardson, B.A., Klopfenstein, N.B., Zambino, P.J., McDonald, G.I., Geils, B.W., and Carris, L.M. 2008. The influence of host resistance on the genetic structure of the white pine blister rust fungus, *Cronartium ribicola*, in western North America. Phytopathology 98: 413-420; and 3) Kim, M.-S.; Geils, B.W.; Klopfenstein, N.B.; Spaine, P.W.; Richardson, B.A.; Zambino, P.J.; Britton, K.; Walla, J.; Peterson, R.; Bulluc, R.; Magarey, R.; Engle, J., and Smith, K. 2009. Recovery plan for Scots pine blister rust caused by *Cronartium flaccidum* and *Peridermium pini*. National Plant Disease Recovery System.

Holly Kearns

Treasurer and Historian Report for the 57th WIFDWC Business Meeting

Treasurer's Report
John Schwandt

In spite of uncertain budgets in the US and Canada, we had 49 registrants including 39 regular members, and 8 students; and 2 retirees. The following is a summary of transactions for the WIFDWC account from 1/1/2009 to 11/15/2009. I have added Holly Kearns as a co-signer on our bank account in case I am unavailable.

Please note that our Federal Tax Id # is 35-2307554.

TRANSACTION	INCOME	EXPENSES	BALANCE
WIFDWC as of 1/1/2009:			***$15,092.69***
2009 WIFDWC meeting –Durango, CO			
Total registration (less 288.00 refund)	14581.56		
Meeting room rental ($375 pd last yr)		334.07	
Catering; breaks, lunches, socials		3857.59	
Field trip transportation (Thanks to Jacobi)		1438.95	
Outside speaker expenses		998.00	
Banquet		1020.00	
Misc and awards		226.02	
Trinkets, printing, folders, meals for spkrs		793.45	
Balance remaining ($5,913.48)			21006.17
Other Account Activity			
Sales of proceedings	28.00		
Bank Interest/dividends	50.09		
Printing/mailing 2007 proceedings		2431.60	
WIFDWC Balance as of 11/15/09			***$18,652.66***
09 proceedings printing/mailing estimate		$2,500??	
Hazard Tree Balance – 10/31/2009			***$971.54***
Total Bank Balance as of 11/15/09 (WIFDWC + Hazard Tree)			**$19,624.20**

Historian's Report
Rona Sturrock

I think this may be the first time a WIFDWC Historian (or designate) has given a report at the annual business meeting but I could stand to be corrected on this. I'm not sure what my fellow WIFDWCers or indeed, the WIFDWC 'Bylaws' want or need the Historian to report on but I expect that this may be a point of discussion this morning.

To prepare this report I started with a look at the publication titled 'WIFDWC – A Brief History and Index to Proceedings 1-40' produced by Frank Hawksworth, John Laut, and Susan Frankel in 1993 as an adjunct to the proceedings from the 1992 meeting, also held in Durango! This publication has an enlightening and very readable 14 page history of our organization, which I invite you all look at, newcomers and old-timers alike. Other sources of information on the history of WIFDWC can be found in the 1970 and 1972 Proceedings -

these provide accounts of WIFDWC's formative years, as presented by Ray Foster. Details of the objectives and organization of WIFDWC are given in the 1957 Proceedings. Members like Susan Frankel may be aware of other historical summaries and/or accounts.

Now, moving on to the 'WIFDWC Historian Position' itself, I unofficially inherited it when Duncan Morrison retired from the Canadian Forest Service (CFS) in 2004, and I seem to recall being officially voted into the position last year in Missoula! Prior to 1973, when Duncan likely inherited the position, it was held by another CFS Scientist, Dr. Gordon (Gordie) Wallis. I'm not sure if Gordie was the first WIFDWC Historian? Perhaps someone here today can answer this question.

Exactly what the function of the WIFDWC Historian is I'm not quite sure but this is likely written down somewhere. A few of the duties that do seem to exist – and I became aware of these when Duncan cleaned out his office and needed a new home for several items – are as follows:

1. The WIFDWC Historian is responsible for collecting and keeping a hard (versus electronic) copy of the Proceedings from each annual meeting. I inherited from Duncan at least one hard copy of each of the Proceedings, starting with the first meeting in Victoria in 1953 and ending with the 48^{th} annual meeting in Hawaii in 2000. If this is a function that we agree should be continued then I need to get hard copies of WIFDWC Proceedings for the last 9 years, including 2009!

2. The WIFDWC Historian is the keeper of anything deemed to be a WIFDWC historical relic (this does not include Walt Thies☺ nor any members' field gear!) – currently, the organization's relics include a pink & purple cloth sack containing three items: 1) a colourful, woven, skull-type cap, 2) a burgundy, silk tie decorated with drawings of mushrooms and butterflies, and inside which is written "Vivian Muir, 1972" and, 3) a pine wood 'cookie', on which is written:

   SOCIAL HOUR
   ACHIEVEMENT
   AWARD
   1958

   6^{TH} W.I.F.D.W.C.

   The cookie also has engraved into it the initials R.H. and V.N. and drawings of a wine glass and a liquor bottle.

   It appears that this Award was first given in 1957 to Stuie Andrews and last given in 1992 to Pete Angwin. The Social Achievement Award was replaced by the Outstanding Achievement Award (in 1993?).

3. The WIFDWC Historian is the keeper of some historical black and white group photographs from past meetings, and a variety of other written remembrances and documents.

4. I seem to recall that the Historian was the keeper of a large, wooden box that contained a gavel and a portable podium? I delivered this box to someone (perhaps Ellen Goheen?) a few years ago and it may also be considered a WIFDWC relic??

That's all that's in my possession right now. I look to you all for guidance and/or clarification on the future role of the WIFDWC Historian!

Best regards and my thanks again to Mike Cruickshank for wearing many hats at this year's meeting,

Standing Committees and Chairs, 1994—2009

Committee	Chairperson	Term
Hazard Trees	J. Pronos	1994–2005
	P. Angwin	2006–2009
Dwarf Mistletoe	R. Mathiasen	1994–2000
	K. Marshall	2001–2003
	F. Baker	2004–2007
	G. Filip	2008
	F. Baker	2009
Root Disease	G. Filip	1994–1995
	E. Michaels Goheen	1996–2005
	B. Ferguson	2006–2009
Rust	J. Schwandt	1994, 2005
	R. Hunt	1995–2004
	H. Kearns	2006–2009
Disease Control*	B. James	1995–2002
Nursery Pathology	B. James	2002–2005
	K. Mallams	2007–2009
Ad Hoc Committees 2008/2009		
Climate Change	T. Shaw	2007
	T. Shaw, D. Shaw, S. Frankel	2009
Foliar and Shoot Diseases	H. Kope	2007–2009

*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—2009

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 (1998-2008) R. Sturrock (2009)	
47	1999	Breckenridge, CO	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		
57	2009	Durango, CO	G. Filip	J. Adams	J. Schwandt	D. Shaw	K.Burns B.Jacobi J.Worrall R.Mask J.Blodgett		

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.

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Robert Bega
Warren Benedict
John Bier
Bill Bloomberg
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Elmer Canfield
Ross Davidson
Oscar Dooling
Norm Engelhart
Ray Foster
Dave French
Lake S. Gill
Clarence "Clancy" Gordon
John Gynn
John Hansbrough
Hans Hansen
Homer Hartman
George Harvey
Frank G. Hawksworth
Dwight Hester
Tommy Hinds
Brenton Howard
John Hunt
Paul Keener
James Kimmey
Don Leaphart
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Jim Mielke
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Vergil Moss
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Nagy Oshima
Lee Paine
John Palmer
Clarence Quick
Lew Roth
Dave Schultz
Charles G. Shaw
Albert Slipp
Willhelm Solheim
Albert Stage
Phil Thomas
Willis Wagener
Charles "Doc" Waters
Larry Weir
Ed Wicker
John Woo
Ernest Wright
Wolf Ziller


WIFDWC
2009

Bottom Row (left to right): Fred Baker, Jessie Micales-Glaeser, Mary Lou Fairweather, Jim Hoffman
Row 2: Leif Mortenson, Jim Blodgett, Betsy Goodrich, Christy Cleaver, Anne Marie Casper
Top Row: Bill Jacobi, Phil Cannon, Brent Oblinger, Anna Schoettle, Kelly Burns, Mike McWilliams, Mike Cruickshank

Bottom Row (left to right): Dave Russell, John Hart, Drew McMahan, Ros Wu, Ned Klopfenstein
Row 2: Eric Smith, Robin Mulvey, Katy Mallams, Marianne Elliott, Jim Worrall, Mee-Sook Kim, Helen Maffei
Row 3: Scott Golden, John Withrow, John Haight, Mike McWilliams, Kristen Chadwick, Greg Filip
Top Row: Suzanne Bethers, Bruce Moltzan, Marcus Jackson

Bottom Row (left to right): Walt and Gail Thies, Judy Adams, Diane Hildebrand
Row 2: Jennifer Klutsch, Will Littke, Dave Shaw, Anna Leon
Top Row: Meg Dudley, Dave Conklin, Not shown (Holly Kearns)

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Drew McMahan and
Bill Jacobi
for the Wonderful Photos