Proceedings

NAFIWC 2011
Bridges to the Future
Portland, Oregon

May 9-12, 2011

Not for citation -- Information is for work conference members only

Proceedings updated: February 6, 2012

2011 North American Forest Insect Work Conference

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Jaime Villa-Castillo – *CONAFOR, Zapopan, Jalisco, Mexico*

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INTRODUCTION and OPENING REMARKS

The fifth North American Forest Insect Work Conference was held in Portland, OR, May 9-12, 2011, at the Portland Marriott Downtown Waterfront. This meeting followed highly successful meetings in Denver, Colorado (1991); San Antonio, Texas (1996); Edmonton, Alberta (2001); and Asheville, North Carolina (2006). Despite challenges limiting the ability of some of our colleagues to travel related to the prevailing economic climate, over 270 attendees from Canada, Mexico, Norway, Sweden, and the US participated in the meeting.

The meeting was again a success due to the commitment of all the organizers, session moderators, presenters, and attendees who convened to share the latest forest entomology related information. The continuing support for this meeting from the forest entomology community attests to its value in promoting the health of our discipline and to the visionary leadership of Doug Allen and Larry Abrahamson who were the driving forces in organizing the first meeting in Denver.

This meeting is a true grassroots effort. There is no formal North American Forest Insect Work Conference organization, no governance structure, and no continuing source of financial support. The meeting happens because the members of the forest entomology community and, specifically, the four regional forest entomology groups, the Northeastern Forest Pest Council, North Central Forest Pest Workshop, Southern Forest Insect Work Conference, and Western Forest Insect Work Conference, value this forum for the exchange of information and ideas.

See you all in 2016!

Darrell Ross

Chair, NAFIWC 2011 Organizing Committee

PROGRAM

Monday, May 9

Registration *2:00 – 7:00*
Poster Set-up *3:00 – 7:00*
Southern Forest Insect Work Conference Business Meeting *4:00 – 5:00*
Opening Reception *5:00 – 7:00*

Tuesday, May 10

Registration *7:00 – 12:00* **and** *5:00 – 6:00*
Continental Breakfast *7:00 – 8:00*
Poster Set-up *8:00 – 12:00*

Plenary Session *8:00 – 12:00*

Welcome and Opening Remarks: Darrell Ross, NAFIWC 2011 Organizing Committee Chair

1. Bridging Generations: Perspectives on Forest Entomology from Junior and Senior Scientists

Moderator: Daniel A. Herms

Impact of Top-Down and Bottom-Up Factors on the Performance of the Exotic Brown Spruce Longhorn Beetle, *Tetropium fuscum* (F.) -- Leah Flaherty, Jon Sweeney, Dan Quiring, and Deepa Pureswaran

Forest Insect Population Dynamics: Understanding Processes and Does Anybody Really Care Anymore? -- Andrew Liebhold

Root Herbivory, Black-Legged Ticks, and Lyme Disease: an Ecological Cascade in Red Pine Forests -- David R. Coyle, Susan M. Paskewitz, Robert J. Murphy, Xia Lee, and Kenneth F. Raffa

Bridging the Generations: Continuing our Traditions of Leadership in Forestry, Ecology, and Entomology into the 21st Century -- William J. Mattson

The Elusive Red Oak Borer: a Story Interpreted through Host Trees -- Laurel J. Haavik and Fred M. Stephen

Science, Students, and Southern Forest Entomology -- Frederick M. Stephen

Genetic Variation of Lodgepole Pine (*Pinus contorta* var. *latifolia*) Chemical and Physical Defenses that Affect Mountain Pine Beetle, *Dendroctonus ponderosae*, Attack and Tree Mortality -- Daniel S. Ott, D.P.W. Huber, A.D. Yanchuk, and K.F. Wallin

Heritage and Mentorship: Back to the Future -- B. Staffan Lindgren

Concurrent Session 1 1:30 – 3:00

2. Ongoing Research and Management of Non-Native Invasive Forest Insect Pests

Organizer: Scott M. Salom

Are Native Natural Enemies Slowing Down the Population Growth Rate of Emerald Ash Borer in North America? -- Jian J Duan, Leah Bauer, Kris Abell, Juli Gould, and Roy Van Driesche

Exploration and Evaluation of Potential Candidates for Biological Control of *Anoplophora* spp. -- Michael T. Smith, Franck Hérard, Matteo Maspero, Ellen Aparicio, Daria Tatman, and Jinquan Wu

Recent Advances and Emerging Issues in Biological Control of Hemlock Woolly Adelgid -- Scott Salom, Gina Davis, Melissa Fischer, Ligia Vieira, Nathan Havill, David Mausel, Ashley Lamb, and L. T. Kok

Nematodes, Fungi, and *Sirex noctilio* -- Ann Hajek and Dave Williams

Potential for Biological Control for the Goldspotted Oak Borer, *Agrilus auroguttatus*, in California -- Tom W. Coleman, Vanessa Lopez, Paul Rugman-Jones, Richard Stouthamer, Steven J. Seybold, and Mark Hoddle

Population Dynamics and Biological Control of Winter Moth, a New Invasive to the Northeastern US -- Joe Elkinton and George Boettner

3. Forest Insect Eradication: Theory and Practice

Organizer: Patrick C. Tobin

Determinants of Cost and Success in Forest Insect Eradication Programs -- Patrick C. Tobin, John Kean, Daniel A. Herms, Danny Lee, Deborah G. McCullough, Therese Pluess, D. M. Suckling, and Takehiko Yamanaka

Eradication is Possible: the Gypsy Moth Success Story in Oregon -- Helmuth W. Rogg and Alan D. Mudge

Balancing Detection vs. Treatments in Eradication Programs -- Andrew M. Liebhold, Becky Epanchin-Niell, Robert Haight, Alan Hastings, John Kean, Takehiko Yamanaka, Julie Blackwood, and Ludek Berec

Bark and Wood Boring Insects Knocking on the Door of New Continents – Can We Stop Them? Bjørn Økland, Olav Skarpaas, and Nadir Erbilgin

4. Bridging Disciplines, Trophic Levels, and Millennia: an Evolutionary Approach to Forest Pest Management

Organizers: Nathan Havill, Melody Keena, and Kimberly Wallin

Introduction to Evolutionary Approaches to Forest Pest Management -- Nathan Havill

Evolutionary Legacies, Global Change, and a New World of Forest Pestilence -- Matt Ayres

Attack by Two Invasive Insects on Eastern Hemlock: Ecological and Evolutionary Processes behind the Interaction -- Sara Gomez, Colin Orians, and Evan Preisser

Evolutionary Approaches to Understanding Ash-Emerald Ash Borer Interactions -- Enrico Bonello

5. Names have Power: the Past, Present, and Future Classification of North American Bark Beetles and its Role in Designing Effective Management

Organizers: Brian Sullivan and Anthony Cognato

Systematics' Role in Designing Effective Management for Bark Beetles -- Brian Sullivan

The Name IS the Game: Taxonomic Uncertainties, the Hobgoblins of Applied Entomology --Jim Labonte

Reproductive Isolation and Genetic Differences among *Dendroctonus ponderosae* Populations: Why Does It Matter? -- Barbara Bentz

The need for bark beetle systematics for detection and identification of non-native species -- Robert Rabaglia

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6. Names have Power: the Past, Present, and Future Classification of North American Bark Beetles and its Role in Designing Effective Management *(continued)*

Organizers: Brian Sullivan and Anthony Cognato

Delimitation and Identification of Scolytine Species with DNA Data -- Anthony Cognato

Taxonomic Confusion among the North American Conifer-Feeding *Scolytus* -- Sarah Smith

Electronic Delivery of Taxonomic Information to End Users -- Thomas Atkinson

7. Invasive Wood Borers: What We Know and Don't Know

Organizer: Melissa K. Fierke

Emerald Ash Borer: Biology, Detection, Management, and Ash Mortality -- Therese Poland, Deb McCullough, and Daniel A. Herms

***Sirex noctilio*: Biology, Parasitism and our Native Siricids** -- Melissa Fierke, Kamal Gandhi, and Matt Ayers

Asian Longhorned Beetle: Biology, Detection and Eradication -- Steve Teale

Goldspotted Oak Borer: What We Still Don't Know about Biology, Detection, and Management -- Tom Coleman and Steven J. Seybold

8. Genetics of Bark Beetles and Associated Microorganisms

Organizers: Ken Raffa and Barbara Bentz

Mountain Pine Beetle Genomics -- Chris Keeling

Insights into the Biology of the Mountain Pine Beetle *(Dendroctonus ponderosae)* through Transcriptome Sequencing -- Mike Pfrender

Mountain Pine Beetle System Genomics: Spatial Genetic Analysis of the Outbreak in Western Canada -- Brent Murray

***Grosmania clavigera* Genome, Physiology and Ecology: What We have Learned about the Diversity of this Bark Beetle Associate and Pine Pathogen** -- Colette Breuil

Poster Session and Complementary Mixer *5:00 – 7:30*

Wednesday, May 11

Continental Breakfast *7:30 – 8:30*

Plenary Session *8:30 – 10:00*

9. Thirty-Plus Years of Research on Tree Defense Mechanisms: Now What?

Organizers: Nadir Erbilgin, Enrico Bonello, and Paal Krokene

Thirty-Plus Years of Research on Tree Defense Mechanisms: Now What? -- Nadir Erbilgin, Enrico Bonello, and Paal Krokene

Genetics, Environment, and G x E Effects on Chemical Defenses in *Populus* -- Richard Lindroth

Resource Allocation in Tree Defense: Scaling from Molecules to Whole Plant -- Daniel A. Herms

Deploying Genetic Resistance: Current Practice and Results, and Future Opportunities -- Richard A Sniezko and John King

Concurrent Session 3 *10:30 – 12:00*

10. Thirty-Plus Years of Research on Tree Defense Mechanisms: Now What? *(continued)*

Organizers: Nadir Erbilgin, Enrico Bonello, and Paal Krokene

Genomics of Induced Defense in Poplars: Complexity and Functionality -- C. Peter Constabel

Evidence for the Natural Occurrence of Systemic Induced Resistance in Populations of *Pinus radiate* -- T.R. Gordon

Phenolic Metabolites – Multiple Functions and Implications for Landscape Ecology -- Johanna Witzell

The Carbon Starvation Hypothesis and How it Relates to Theories of Host Defense -- Monica Gaylord, Thomas Kolb, and Nate McDowell

11. Insects in Forest Landscapes: Causes and Consequences of Insect Outbreaks

Organizers: Robert N. Coulson and Frederick M. Stephen

The Forest Landscape Insect Interaction Perspective -- Robert Coulson and Fred Stephen

Climate/Beetle Disruption of Adaptive Disturbance Regimes in Whitebark Pine -- Jesse Logan

Forest Insect Outbreaks and Carbon Dynamics -- Allan Carroll and Werner Kurz

Gypsy Moth to Insect Invaders of the Northeast -- Andrew Liebhold

Causes and Consequences of a Red Oak Borer Outbreak in the Mountains of Arkansas -- Fred Stephen, M. K. Fierke, L. J. Haavik, and J. J. Riggins

Impacts of EmeraldAsh Borer in the Great Lakes Region -- Andrew Storer

Herbivory and the Hemlock Woolly Adelgid: What Happens When the Hemlocks are Gone? -- Robert Coulson, Yu Zeng, A. Birt, M. Tchakerian, C. Lafon, D. Cairns, J. Waldron, and D. Streett

12. How's your Aspen? Patterns of Dieback and Decline in Western North America

Organizer: Robbie W. Flowers

Damage Agents and Condition of Mature Aspen Stands in Montana and Northern Idaho -- Brytten E. Steed and Holly S. J. Kearns

Update on Aspen Decline and Mortality in Colorado -- Sheryl L. Costello

Evaluating Aspen Damage and Decline in the Pacific Northwest -- Glenn R. Kohler and Robbie W. Flowers

The Decline of Aspen in Central Arizona -- Mary Lou Fairweather, Ryan P. Hanavan, and Brian W. Geils

13. Interactions between Ecosystem Disturbances and Forest Insects

Organizers: Kamal J.K. Gandhi, Barbara Bentz, and Kenneth F. Raffa

Introduction: Current Paradigms Related to Ecosystem Disturbances and Forest Insects -- K.J.K. Gandhi

Interactions between a Catastrophic Wind-Disturbance Event, Fuel-Reduction Activities, and Sub-Boreal Insects -- K.J.K. Gandhi, D.W. Gilmore, R.A. Haack, S.A. Katovich, S.J. Krauth, W.J. Mattson, J.C. Zasada, and S.J. Seybold

Does Wildfire Promote Outbreaks by Tree-Killing Bark Beetles? -- K.F. Raffa, B.J. Bentz, D. Blackford, A. Lerch, and E.N. Powell

Patterns of Fire and Bark Beetle Mortality in the Greater Yellowstone Ecosystem -- P.A. Townsend, M. Simard, E.N. Powell, K.F. Raffa, and M.G.Turner

The Influence of Mountain Pine Beetle Outbreaks on Carbon and Nitrogen Cycling in Lodgepole Pine Ecosystems -- M. Hansen, M. Amacher, M. Ryan, H.V. Miegroet, M. White, and J. Long

Concurrent Session 4 *1:30 – 3:00*

14. Native Invasive Bark Beetles: Consequences of Range Expansion

Organizers: Staffan Lindgren and Daniel A. Herms

Introduction -- B. Staffan Lindgren

The Role of "Defense Free Space" in Devastating Insect Invasions of North American Forests -- Daniel A. Herms

Climatic Perturbation and Positive Feedback in Eruptive Bark Beetle Populations -- Allan L. Carroll

Increased Susceptibility and Suitability of Naïve Lodgepole Pine to Mountain Pine Beetle -- Staffan Lindgren, Niklas Björklund, Allan Carroll, and Timothy Cudmore

Differences in the Terpene Profiles of Lodgepole Pines in British Columbia and their Correlation with Historical Attacks by Mountain Pine Beetles -- Erin Clark, Allan Carroll, and Dezene Huber

How Does Invasion of Jack Pine by Mountain Pine Beetle Affect Jack Pine Defenses? -- Nadir Erbilgin, Inka Lusebrink, and Maya Evenden

Climate Mediated Ecological Role Shift for Mountain Pine Beetle in High Elevation Forests -- Jesse Logan

15. Walnut Twig Beetle and Thousand Cankers Disease: Framing the Response to a Serious Threat to our Valuable North American Walnut Resource

Organizer: Steven J. Seybold

Introduction -- Steven J. Seybold

Distribution, Diversity, and Utilization of Walnut Genetic Resources, the Most Pressing Threats, and the Prospect for Genetic Improvement of Black Walnut Species Against Thousand Cankers Disease -- Charles A. Leslie

Epidemiology of Thousand Cankers Disease: the Fungal Aspect, Biology of the Pathogen, Outreach, and Implications for Forest Management -- Ned A. Tisserat

Walnut Twig Beetle: Just Where did this Hyperactive Vector Come From? -- Steven J. Seybold

Developing the *National Response Framework for Thousand Cankers Disease (TCD) on Walnut:* Administrative and Technical Challenges -- Bruce Moltzan

Thousand Cankers Disease: Developing a Statewide Response in America's Black Walnut Breadbasket -- Collin Wamsley

Panel Discussion: What Should be our Research, Outreach, and Administrative Responses to Thousand Cankers Disease in the Next Five Years?

16. Secondary Effects of Exotic Invasions - Cascades of Ecological Change

Organizers: Joshua K Adkins and Lynne K. Rieske-Kinney

Hemlock Woolly Adelgid Threatens the Integrity of Headwater Riparian Invertebrate Communities -- Joshua K. Adkins and Lynne K. Rieske-Kinney

Invasive Ant-Native Hemiptera Mutualisms Threatens the Arthropod Community and Ecosystem Functioning of a Previously Unsuitable Forest Habitat -- John Brightwell

The Impacts of Cryptic Invaders: Birch Leafmining Sawflies in North America -- Christian MacQuarrie

Oak Mortality and Two Borers: a Co-evolved Relationship in the Eastern U.S. and an Introduced Relationship in the Western U.S. -- Laurel J. Haavik, Fred M. Stephen, Tom W. Coleman, Mary Louise Flint, Robert C. Venette, and Steven J. Seybold

Invasive Pathogen in Whitebark Pine Ecosystems: Trophic Cascades and Functional Losses -- Diana F. Tomback and Shawn T. McKinney

17. Bark Beetles and Stand Structure Following Thinning in Coniferous Forests

Organizers: Christopher J. Fettig, A. Steven Munson, and John T. Nowak

Why All Thinnings are Not Created Equal – Factors Influencing the Susceptibility of Forest Stands to Bark Beetle Infestations -- Christopher J. Fettig, A. Steven Munson, and John T. Nowak

A Canadian Silviculturist's Perspective on the Effectiveness of "Thinning" to Reduce Susceptibility to Mountain Pine Beetle (*Dendroctonus ponderosae* Hopk.) -- Roger J. Whitehead and Greg D. Smith

Effect of Stand Density on In-Stand Gas Concentrations: Experience Using an Atmospheric Tracer in Forest Canopies -- Harold W. Thistle, Tara Strand, and Brian L. Strom

Modeling Southern Pine Beetle Activity under Different Thinning Regimes and Planting Densities -- James R. Meeker, John W. Bishir, and Brian L. Strom

Concurrent Session 5 *3:30 – 5:00*

18. What Kills Bark Beetle-Attacked Trees and Why it Matters

Organizers: Richard Hofstetter and Monica Gaylord

Introduction: How do Bark Beetle-Attacked Trees Die? -- Richard Hofstetter

Competing Theories on the Relative Importance of Microbes and Bark Beetles -- Paal Krokene

How Can We Best Test Whether Fungi Assist Bark Beetles in Contending with Tree defenses? Ideas Welcome! -- Ken Raffa

Management Implications: Does it Matter How Trees Die? -- Kier Klepzig

19. Changing Climates and Trophic Interactions

Organizers: Patrick C. Tobin and Brian H. Aukema

Introduction -- Patrick Tobin

Effects of Climate Change on Species Interactions -- Daniel A. Herms

The Role of Plant Defenses Mediating Interactions Between an Invasive Insect and a Community of Native Organisms in Boreal Forest -- Nadir Erbilgin and Jessie Colgan

Climatic Variation and Species Interactions in a Northern Hardwood Forest -- Nina Lany and Matt Ayres

Multitrophic and Community Structure Responses to Climatic Variation: Past and Potential Ecological Changes in Forests -- R. Talbot Trotter III, Alexander Evans, Gina Wimp, and Thomas G. Whitham

20. Informing Current Research on Wood and Bark-Boring Beetles with Lessons from the Past

Organizers: Chris J. K. MacQuarrie and Krista Ryall

Bark Beetle Disturbance in Quebec and Atlantic Canada - Can the East Compete with the West? -- Deepa Pureswaran and Jon Sweeney

Historical Perspective on Native and Exotic Bark and Wood Boring Beetles in Ontario -- Sandy Smith and Krista Ryall

Ecology and Management of the Mountain Pine Beetle and Spruce Beetle: Some Highlights of Past Research in British Columbia -- Bill Riel and Les Safranyik

A Semiochemical View of the Northern Spruce Engraver, *Ips perturbatus* (Coleoptera: Scolytidae), in Alaska: from Attraction, to Interruption, to Tree Protection -- Andrew Graves

Historical View of Research in Forest Entomology: Turning Limitations and Future Directions into a Potential Research Idea -- Nadir Erbilgin

Discussion: Passing the Torch. Using the previous talks as a reminder of historical research, the panel and audience will discuss the question: How is bark beetle research as done today informed by the work of the past?

21. *Sirex* in North America: a Conversation on Current Research

Organizers: Frederick M. Stephen and Ann E. Hajek

This workshop will provide a forum for unstructured discussion and conversation on current ongoing research on *S. noctilio*, native Siricidae, and their natural enemies and associates. The intent of the workshop is to enable researchers and graduate students to learn what their colleagues in different institutions are doing. The workshop is planned as a 1.5 hour discussion, without PowerPoint presentations, but rather focused on quick summaries of methods, results and plans for studies being conducted by researchers and students at different institutions.

Student Poster Competition Judging *5:00 – 6:00*

Banquet *6:30 – 9:30*

Keynote Speaker: Peter Frenzen
Monument Scientist / Public Affairs Officer,
USDA Forest Service, Mount St. Helens National Volcanic Monument

"Mount St. Helens: Three Decades of Ecosystem Reassembly and Landscape Change"

Thursday, May 12

NAFIWC Business Meeting and Student Awards *8:00 – 8:30*

Plenary Session *8:30 – 10:00*

22. Bark Beetles and Fire Interactions in Western Coniferous Forests: Effects

Organizers: Christopher J. Fettig and Robert A. Progar

Effects of Fuel Reduction Treatments on Bark Beetle Activity in the Western U.S. -- Christopher J. Fettig

The Role of Bark Beetles and Wood Borers in the Survival of Fire-Injured Trees in Oregon and Washington -- Robert A. Progar and Lisa M. Ganio

Predicting Mortality for Five California Conifers Following Wildfire -- Sharon M. Hood, Sheri L. Smith, and Daniel R. Cluck

A Holocene Record of Spruce Beetles, Wildfire and Vegetation from a High Elevation Basin in the Wasatch Plateau, Utah -- Jesse L. Morris, Andrea Brunelle, A. Steven Munson, and Mitchell J. Power

Concurrent Session 6 *10:30 – 12:00*

23. Bark Beetles and Fire Interactions in Western Coniferous Forests: Fuels and Fire Risks

Organizers: Christopher J. Fettig and Robert A. Progar

Impact of a Pinyon Ips Outbreak on Fuels and Wildfire Potential in Piñon-Juniper Woodlands of Arizona -- Joel D. McMillin, Chad Hoffman, Carolyn H. Sieg, Rod Linn, and Pete Z. Fulé

Temporal Dynamics of Ground, Surface, Ladder, and Crown Fuels and their Potential Effects on Fire Behavior, Following *Dendroctonus ponderosae* Epidemics in the *Pinus contorta* Zone of South-Central Oregon -- David Shaw, Travis Woolley, Stephen A. Fitzgerald2, and Laurie L. Kurth

Comparing Bark Beetle (*Dendroctonus* spp.) Impacts on Wildfire Potential in Lodgepole Pine and Douglas-fir Forests of Greater Yellowstone -- Daniel C. Donato, Martin Simard, Monica G. Turner, William H. Romme, Brian J. Harvey, and Jake M. Griffin

The Impact of Spruce Beetle on Fuels and Fire Behavior in Intermountain Engelmann Spruce Forests -- Michael J. Jenkins and C. Arik Jorgensen

24. Single Tree Protection Tactics

Organizer: Donald Grosman

Introduction -- Donald Grosman

The Latest Insecticides for Tree Protection -- Daniel A. Herms

Protecting Individual Conifers from Bark Beetle Attack using Bole Sprays and Systemic Tree Injections -- Christopher J. Fettig, Donald M. Grosman, A. Steve Munson, and C. Wayne Berisford

Control Options for Exotic Borers -- Therese Poland and Deborah McCullough

Testing Systemic Insecticides for Management of Three Common Pests in Conifer Seed Orchards of the Intermountain West -- Stephen Cook, Ben Sloniker, and Marc Rust

Markets and Regulatory Challenges Regarding Tree Protection Tactics -- David L. Cox, S.W. Cosky, J. Overmyer, T. Parshley, D. Steltz, and W. Teoli

25. Potential for Breeding Resistance to Invasive Forest Pests

Organizer: Fred Hain

Historical Perspective on Breeding Trees Resistant to Forest Pests -- Richard Sniezko

Breeding Resistance to Chestnut Blight: a Success Story -- Fred Hebard

The Role of Gene Conservation in Developing Breeding Resistance Programs -- Robert Jetton

Developing Hemlocks Resistant to Hemlock Woolly Adelgid -- Fred Hain

Potential for Breeding Resistance to Emerald Ash Borer -- Jennifer Koch

Work Conference Adjourned -- *12:00 pm*

PLENARY SESSIONS and CONCURRENT SESSIONS

Session 1 – Plenary Session

Bridging Generations: Perspectives on Forest Entomology from Junior and Senior Scientists

Organizer: Daniel A. Herms

Department of Entomology, The Ohio State University, Wooster, OH

A junior and senior scientist selected from each region by nominating committees will present their perspective on forest entomology in their respective regions.

Impact of Top-Down and Bottom-Up Factors on the Performance of the Exotic Brown Spruce Longhorn Beetle, *Tetropium fuscum* (F.)

Leah Flaherty[1,2], Jon Sweeney[2], Dan Quiring[1], and Deepa Pureswaran[3]

[1]Faculty of Forestry and Environmental Management, University of New Brunswick, Fredericton, NB; [2]Natural Resources Canada, Canadian Forest Service, Atlantic Forestry Centre, Fredericton, NB; [3]Natural Resources Canada, Canadian Forest Service, Laurentian Forest Centre, Sainte-Foy Québec, QC

In its native Europe, *Tetropium fuscum* (F.) (Coleoptera: Cerambycidae) primarily colonizes weakened Norway spruce, *Picea abies* (L.) Karst., and is not considered a pest. In Canada, this exotic beetle can kill apparently healthy red spruce, *Picea rubens* Sarg., and has been classified as a quarantine pest since 2000. Any mechanisms allowing *T. fuscum* to colonize healthier trees in Canada than in Europe are unknown, but may be related to its colonization of a novel North American host (bottom-up factor) and/or its new natural enemy complex (top-down factor). We are investigating the impact of these factors on *T. fuscum* performance in Canada using manipulative field experiments. Specifically, we exposed developing *T. fuscum* to different host tree species (native versus novel host), tree conditions (stressed versus healthy), and levels of protection from natural enemies and competitors, and evaluated subsequent performance (stage-specific survival and mortality factors). Complimentary experiments evaluate adult oviposition preference on different host species and conditions.

Results suggest that on the novel host, the impact of natural enemies is mediated by the physiological condition of the host. *Tetropium fuscum* survival is higher on stressed than on healthy trees when protected from parasitoids, likely due to reduced tree defenses. However, survival of unprotected *T. fuscum* was higher on healthy trees than on stressed trees, due to greater parasitism rates on stressed trees. Although *T. fuscum* adults are larger and parasitism is lower on healthy than on stressed trees, development time is extended, reducing fitness. Experiments evaluating the effect of host species are ongoing, but preliminary results indicate that early-instar larval survival is reduced on the native host (Norway spruce) compared to the novel host (red spruce). In both host species there is an effect of timing of attack on *T. fuscum* survival, where earlier attacking larvae have lower survival rates than those attacking later in the spring, likely due to variations in host defensive response.

This research examines complex novel ecological interactions among three trophic levels: an exotic herbivore, its host plant and its natural enemies. It will improve our understanding of the

ecology of cerambycids, which are scarcely studied due to their cryptic nature and long generation times, despite their economical importance. This research also contributes to the development of T. fuscum phenology and population growth models at the Canadian Forest Service, and is considered a priority by the Canadian Food Inspection Agency for defining the risk to spruce forests posed by T. fuscum. The research has been funded by the Canadian Forest Service, Canadian Food Inspection Agency, NSERC, Forest Protection Limited, Nova Scotia Department of Natural Resources and Ontario Ministry of Natural Resources.

Forest Insect Population Dynamics: Understanding Processes and Does Anybody Really Care Anymore?

Andrew Liebhold

USDA Forest Service, Northern Research Station, Morgantown, WV

{No abstract submitted.}

Root Herbivory, Black-Legged Ticks, and Lyme Disease: an Ecological Cascade in Red Pine Forests

David R. Coyle[1], Susan M. Paskewitz[2], Robert J. Murphy[2], Xia Lee[2], and Kenneth F. Raffa[2]

[1]D.B. Warnell School of Forestry and Natural Resources, University of Georgia, Athens, GA; [2]Department of Entomology, University of Wisconsin, Madison, WI

{No abstract submitted.}

The Elusive Red Oak Borer: a Story Interpreted through Host Trees

Laurel J. Haavik[1] and Fred M. Stephen[2]

[1]Department of Entomology, University of California, Davis, CA; [2]Department of Entomology, University of Arkansas, Fayetteville, AR

As a recent graduate, my perspective as a junior Forest Entomologist comes mainly from my dissertation research. Though heavily focused on using forest ecology and dendrochronology to understand an entomological problem, my project was lacking in actual insects. I arrived in Dr. Fred Stephen's lab trailing a large cohort of students whose projects were focused on understanding the biology and ecology of a native forest insect outbreak in the Arkansas Ozark Mountains. The red oak borer (*Enaphalodes rufulus* (Haldeman)) had never before been associated with an oak mortality event and, prior to the work of Dr. Stephen and these students; little was known about this insect outside of its distribution, basic biology and a short list of its natural enemies.

With no trace of red oak borer, the outbreak was clearly over yet many questions remained. We employed an historical approach through the use of tree-rings to understand the role of forest history, climate and host resistance on red oak borer population dynamics. Evidence of larval galleries left behind in tree-rings dateable to the year of larval presence allowed us to detect population levels throughout the past century and compare them to host tree growth patterns and climate relations. We discovered that drought was favorable for red oak borer population growth and a severe drought in the early 1950s initiated growth decline and deteriorating

climate relations of host trees. Borer populations began building within host trees in the mid-1970s, yet they were not detectable at the forest level until 1999 when host tree mortality first became evident. Suppressed trees died during the red oak borer outbreak, which likely resulted in reduced resource competition for neighboring healthy trees. Healthy trees experienced a growth release at this time, which enabled them to tolerate feeding pressure from borers and survive the outbreak. These investigations provide some explanation for the unexpected red oak borer outbreak, yet many questions remain unanswered such as the role of natural enemies on regulating borer populations.

Science, Students, and Southern Forest Entomology

Frederick M. Stephen

Department of Entomology, University of Arkansas, Fayetteville, AR

{No abstract submitted.}

Genetic Variation of Lodgepole Pine (*Pinus contorta* var. *latifolia*) Chemical and Physical Defenses that Affect Mountain Pine Beetle, *Dendroctonus ponderosae*, Attack and Tree Mortality

Daniel S. Ott[1,2], D.P.W. Huber[2], A.D. Yanchuk[3], and K.F. Wallin[1,2,4]

[1]The Rubenstein School of Environment and Natural Resources, University of Vermont, Burlington, VT; [2]University of Northern British Columbia, Prince George, BC; [3]British Columbia Forest Service, Victoria, BC - Current address: Scion, Private Bag 3020, Rotorua, New Zealand; [4]USDA Forest Service, Northern Research Station, South Burlington, VT

The mechanisms that affect herbivore feeding include biotic and abiotic factors. Plants that develop characteristics that deter herbivores may have a greater fitness and pass on effective defensive traits to their offspring. The prevalence of these plant defenses may vary over time and among populations. Understanding herbivore life cycles is critical to elucidating plant defense strategies. Typically herbivore life cycles include host selection, host acceptance, and host utilization.

The lodgepole pine, Pinus contorta var. latifolia, forests in British Columbia experience episodic outbreaks of mountain pine beetle (MPB), Dendroctonus ponderosae Hopkins (Coleoptera: Curculionidae), and its associated fungi Grosmannia clavigera (formerly known as Ophiostoma clavigerum). The current study has provided a framework to observe heritable tree characteristics and how they interfere with the life-cycle of MPB. Many tree variables associated with host selection and acceptance such as DBH, tree height, bark texture and MPB landing were not significantly associated with selecting a host and initiating an entry point. However, the frequency of hypersensitivity reactions was negatively correlated with host utilization, including MPB gallery production, reproduction, and brood development. Overall MPB success is determined by tree mortality. It was found that constitutive δ-3-carene and hypersensitivity reactions, occurring in response to MPB attack, negatively impacts MPB host utilization and lowers tree mortality.

Heritage and Mentorship: Back to the Future

Staffan Lindgren

University of Northern British Columbia, Prince George, BC

In my e-mail signature file, I have a quote by the Hungarian physiologist and Nobel laureate Albert Szent-Gyorgyi that reads: ***"Discovery consists of seeing what everybody has seen and thinking what nobody has thought."*** As scientists we get a lot of our information from reading, and we all have access to the same information. We also use the tools developed by those who paved the way, and benefit or are constrained by the paradigms they generated. Thus, we rely on a rich scientific heritage. How we use that heritage is a function of personal abilities and aptitude, but also of the nature and quality of mentorship throughout our lives. Mentors shape us as human beings throughout life, and as scientists once we enter academia. I presented examples of mentors that have been important throughout my career. The young scientists we have heard from earlier in the session are our future, and judging by the excellent quality of their presentations I would say our future is in good hands. Their excellence reflects the rich heritage and good mentorship that they have benefitted from.

Session 2 – Concurrent Session

Ongoing Research and Management of Non-Native Invasive Forest Insect Pests

Organizer: Scott M. Salom

Department of Entomology, Virginia Tech, Blacksburg, VA

We are facing a crisis of tree and forest death with recent introductions of non-native insect pests. While we attempt to learn as much about these pests as possible, we also realize that in some cases we are or potentially will lose some ecosystems. There is limited time to act and we must figure out how to reduce the impact these pests are having in a sustainable way. This workshop will focus on the latest research efforts that may be focused on but not limited to the use of biological control. As much as possible the presentations will be organized in the following way: 1. Brief background of invasive pest; 2. Why biocontrol?; 3. Options/prospects; 4. Stage of activity in investigating or implementing; 5. Problems and advances with the effort; and 6. Final prognosis on what it will take to be successful.

Are Native Natural Enemies Slowing Down the Population Growth of Emerald Ash Borer in North America?

Jian J. Duan[1], Leah S. Bauer[2], Kristopher J. Abell[3], Juli Gould[4], and Roy Van Driesch[3]

[1]USDA ARS, Beneficial Insects Introduction Research Unit, Newark, DE; [2]USDA Forest Service, Northern Research Station, East Lansing, MI; [3]Department of Plant, Soil, and Insect Sciences, University of Massachusetts, Amherst, MA; [4]USDA APHIS PPQ, Buzzard Bay, MA

Life tables of two generations of the invasive emerald ash borer (*Agrilus planipennis*) were constructed from field data collected in central Lower Michigan from 2008 to 2010. Results from analysis of these life tables showed that the exploding EAB population (R_0=17.5) in this area of Michigan was reduced to an expanding population (R_0=3.5) from 2009 to 2010 by several major

native biotic factors: parasitoids primarily *Atanycolus* spp. (Braconidae), woodpeckers, disease, intraspecific competition, and host plant resistance. Modeling of the life table parameters further indicated that an additional 30 – 40% larval parasitism or 70 -80% egg parasitism would result in a stable or declining EAB population (R_0<1). Several species of exotic parasitoids introduced from emerald ash borer's native home (northeast Asia) such as *Tetrastichus planipennisi*, *Spathius spp.,* and *Oobius agrili* appear to have the potential to shrink EAB population in North America.

Recent Advances and Emerging Issues in Biological Control of Hemlock Woolly Adelgid

Scott Salom[1], Gina Davis[1], Melissa Fischer[1], Ligia Vieira[1], Andy Roberts[1], Nathan Havill[2], Bud Mayfield[3], David Mausel[4], Ashley Lamb[5], Scott Costa[6], and L. T. Kok[1]

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The biological control effort for hemlock woolly adelgid (HWA), *Adelges tsugae* Annand (Hemiptera: Adelgidae) was initiated in the early 1990's and has advanced on a number of fronts. *Sasajiscymnus tsugae* Sasaji and McClure (Col.: Coccinellidae) was imported from Japan and has been the most heavily reared and released agent, with numbers reaching over 3,000,000 in the past 16 years. *Laricobius nigrinus* Fender (Col.; Derodontidae), imported from western North America, is more difficult to rear. Around 100,000 adults and an unknown number of eggs have been released since 2003. While there is a tremendous disparity in numbers released between both species, *L. nigrinus* appears to establish better and is much easier to recapture post-release. *L. nigrinus* has become established in 60% of the initial release sites between GA and MA, and appears most suitable for USDA plant hardiness zones 6A, 6B, and 7A. Greater numbers of beetles released per site also increases the chance of the beetles becoming established. An inland strain of this species appears to be better suited for New England than the more commonly released coastal strain. Released *L. nigrinus* stay on or close to the release trees within the first couple of years, eventually dispersing in considerable numbers as far as 300 m within 5 generations. *Laricobius osakensis* Montgomery and Shiyake was discovered in Japan in 2005 and approved for release from quarantine in 2010. Beetles are currently being reared in preparation for its initial release in 2011. In an effort to support the release and monitoring of all these biological control agents, an online database using Oracle Ò 10g with a mapping component using Google Maps Ò has been developed and is operational. It is being used to record all beetle release activities and can be accessed at http://hwa.ento.vt.edu/hwa/hwa.cgi. Some emerging issues with this classical biological control effort include the finding that in hemlock forests containing or near white pine, *L. nigrinus* and *L. rubidus* Leconte (a native predator of *Pineus strobi* (Htg.)) commonly co-occur, and hybridization between these species has been documented to take place. We are currently investigating the long-term consequences of these findings. Impacts on forest health following release of both beetle species has been difficult to document and there is no experimental evidence yet that shows distinct improvement in forest stand health 5 – 7 years after *L. nigrinus* has been released. Continued efforts toward documenting impact are needed. Other management tools being tested include use of generalist fungi as a

biopesticide to help suppress HWA populations. Mycotal (*Lecanicillium muscarium*), formulated in a Mycomax microfactory formulation, has shown good results in trials and will be submitted for registration in the U.S. for forestry use in 2012 or 2013. Lastly, a concept is being tested that looks at a coordinated effort of treating a component of the dominant hemlock stand structure with insecticide and a simultaneous release of biological control agents in the understory. The idea is to give short-term relief to highly valued trees while establishing and building a population of predators.

Nematodes, Fungi, and *Sirex noctilio*

Ann Hajek[1] and David Williams[2]

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{No abstract submitted.}

Potential for Biological Control for the Goldspotted Oak Borer, *Agrilus auroguttatus*, in California

Tom Coleman[1], Vanessa Lopez[2], Paul Rugman-Jones[2], Richard Stouthamer[2], Steven J. Seybold[3], and Mark Hoddle[2]

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Oaks have died at an elevated rate in San Diego Co. since 2002 and led to significant ecological and economic problems for land managers and homeowners. The goldspotted oak borer, *Agrilus auroguttatus* (Coleoptera: Buprestidae), was first linked to continuing oak mortality in 2008. Biological control is being assessed as an option for controlling this invasive species in California. Our current approach is to define the origin of *A. auroguttatus* populations in California and survey its native and introduced regions for populations of the beetle, for populations of natural enemies, and to gather life history information for both trophic levels. Field surveys will continue in all areas with the ultimate goal of developing an "extraordinary" guild of natural enemies for *A. auroguttatus* in California.

Population Dynamics and Biological Control of Winter Moth, a New Invasive to the Northeastern US.

Joe Elkinton and George Boettner

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{No abstract submitted.}

Session 3 – Concurrent Session

Forest Insect Eradication: Theory and Practice

Organizer: Patrick C. Tobin

USDA Forest Service, Northern Research Station, Morgantown, WV

Although there have been several high profile insects for which eradication was not successful, there are numerous examples of successful eradication programs. Invading species often show considerable variability in invasiveness that in turn can affect eradication success. Many new invaders are subject to Allee dynamics, and thus it could be possible to exploit Allee effects to the detriment of an invader. Given the importance of eradication as a strategy to avert costs associated with invasions, this workshop will focus on the theory and practice of forest insect eradication with the goal of highlighting factors that drive success and failure.

Determinants of Cost and Success in Forest Insect Eradication Programs

[1]Patrick C. Tobin, [2]John Kean, [3]Daniel A. Herms, [4]Danny Lee, [5]Deborah G. McCullough, [6]Therese Pluess, [7]D. M. Suckling, and [8]Takehiko Yamanaka

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We gathered information on insect eradication programs around the world, including both successful and unsuccessful programs. Data from over 700 eradication programs were compiled and the resulting data were analyzed to identify patterns in successful and failed attempts. We compiled information on the target species biology and ecology (i.e., life history, mechanisms and rate of spread, the ability to detect the species, climate suitability in the native and introduced area, and type of damage), and details of the eradication program (i.e., location and dates of the program, initial infestation size, control tools used, costs, and outcome). We focused primarily on forest insect eradication programs, but we also had some data on insect eradication programs in other systems. A primary determinant in eradication success was, not surprising, the availability of a detection tool. Species for which a detection tool exists, such as traps baited with semiochemicals, were 9 times more likely to be eradicated than a species for which a detection tool does not exists. Costs of the eradication program increased logarithmically with the initial size of the infestation, and the median cost of all programs was 2 million USD (adjusted to 2005). Furthermore, for every $\log_{10}$ increase in infestation size (i.e., from 1 to 10 ha), the probability of successful eradication decreased two-fold. Programs lasting 4 years or less were more than 3 times more likely to be successful than those lasting longer than 4 years. Programs lasting >12 years were rarely successful. The results of these analyses should provide guidance in the management and coordination of future eradication efforts.

Eradication is Possible: the Gypsy Moth Success Story in Oregon

Helmuth W. Rogg and Alan D. Mudge

Plant Division, Oregon Department of Agriculture, Salem, OR

In 1984, 19,019 gypsy moths, *Lymantria dispar* (L.), were found over 1,200 mi^2 in Lane Co., Oregon - the largest gypsy moth infestation ever found in the western U.S. In 1985, a large-scale eradication program consisting of quarantines, applications of *Bacillus thuringiensis* var. *kurstaki*, posttreatment mass-trapping (3-9 traps/acre in core areas) and delimitation surveys (16 traps/mi^2) within the 1,200 mi^2 quarantine area was initiated. The number of moths trapped and acres

treated declined in each of four successive years: 1985 - 226,405 acres treated, 1,278 moths trapped; 1986 - 189,011 acres treated, 81 moths trapped; 1987 - 7,135 acres treated, 41 moths trapped; 1988 - 2,995 acres treated, 1 moth trapped. In 1989, the quarantine was lifted after two moths were trapped and determined to be recent introductions and not evidence of an incipient population. Since 1984, numerous smaller gypsy moth eradication programs have also been conducted in Oregon. All have been considered successful after two successive years of negative posttreatment surveys of 16-49 traps/ mi^2. Contributing to this success are an effective pheromone capable of detecting populations at low levels, annual statewide surveys conducted on a rotating grid basis, and flightless females (North American strain) resulting in relatively limited natural spread. In many cases the source, means, and time of introduction from an infested state are found within one to two years of an initial trap detection indicating these are new introductions and not an incipient population that may take several years to reach detectable levels.

Balancing Detection vs. Treatments in Eradication Programs

Andrew M. Liebhold

USDA Forest Service, Northern Research Station, Morgantown, WV

{No abstract submitted.}

Bark and Wood Boring Insects at the Gate of New Continents – Can We Stop Them?

[1]Bjørn Økland, [2]Olav Skarpaas, and [3]Nadir Erbilgin

[1]Norwegian Forest and Landscape institute, Ås, Norway; [2]Norwegian Institute for Nature Research, Oslo, Norway; [3]Department of Renewable Resources, University of Alberta, Edmonton, AB

North American bark and wood borers may cause biome-scale ecosystem effects if they should become established in the Eurasian taiga (Økland et al. 2011). The most important tree species of the European taiga, Scots pine (*Pinus sylvestris*), is for example highly susceptible to the mountain pine beetle (*Dendroctonus ponderosae*). Other dominant tree species of the Eurasian taiga, such as Norway spruce (*Picea abies*) and Siberian spruce (*Picea obovata*), are currently attacked by the Eurasian spruce bark beetle (*Ips typographus*). If the North American spruce beetle (*Dendroctonus rufipennis*) should become established in Eurasia, model simulations indicate that interactions with the Eurasian spruce bark beetle could lead to more severe outbreaks than when the native species acts alone (Økland et al. 2011). Attack by the bronze birch borer (*Agrilus anxius*) has led to 100 % mortality of European birch species planted in the US; these tree species cover large areas of the Eurasian continent. Allee effects may explain why many bark beetles have not become established in Eurasia, but more research is needed to fully understand the mechanisms. In other species such as *Agrilus* sp., eradication may be very difficult due to rapid dispersal and delayed detection of attacked trees. Rate of spread and detection delay depend on properties of both insect species and forest ecosystems. Lack of wilting symptoms makes it for example difficult to detect the pinewood nematode in time for eradication in the cold climate of the northern taiga (Økland et al. 2010). Improved phytosanitary measures may reduce the arrivals of serious pests to the Eurasian continent. Model simulations of the wood chip and timber import indicate that wood borers and bark beetles could easily escape detection unless the numbers of samples and traps are very large (Skarpaas & Økland 2009). Chipping to a smaller chip size could stop arrival of species; however, our results indicate that this would require a smaller chip size than in the current requirement.

Økland, B; Skarpaas, O; Schroeder, M; Magnusson, C; Lindelöw, Å; Thunes, K 2010. Is eradication of the pinewood nematode (*Bursaphelenchus xylophilus*) likely? An evaluation of current contingency plans. Risk Analysis 30(9): 1424–1439.

Økland, B; Erbilgin, N; Skarpaas, O; Christiansen, E 2011. Inter-species interactions and ecosystem effects of non-indigenous invasive and native tree-killing bark beetles. Biological Invasions 13(5): 1151-1164

Skarpaas, O; Økland, B 2009. Timber import and the risk of forest pest introductions. Journal of Applied Ecology 46: 55-63.

Session 4 – Concurrent Session

Bridging Disciplines, Trophic Levels, and Millennia: An Evolutionary Approach to Forest Pest Management

Organizers: Nathan Havill[1], Melody Keena[1], and Kimberly Wallin[1, 2]

Speakers: Nathan Havill[1], Matt Ayres[3], Sara Gomez[4], and Pierluigi (Enrico) Bonello[5]

[1]USDA Forest Service, Northern Research Station, Hamden, CT; [2]The Rubenstein School of Environment and Natural Resources, University of Vermont, Burlington, VT; [3]Department of Biological Sciences, Dartmouth College, Hanover, NH; [4]Department of Biological Sciences, University of Rhode Island, Kingston, RI; [5]Department of Plant Pathology, The Ohio State University, Wooster, OH

The impacts of herbivores on tree health occur in the presence of complex multitrophic interactions. The nature of these interactions can be the product of a long shared evolutionary history, or novel interactions due to species introductions, climate change, or other anthropogenic influences. This session explored ways in which attention to evolutionary processes can inform and enhance our ability to manage forest pests. The speakers covered a broad range of temporal, spatial, and taxonomic scales, and their work bridges traditional and contemporary technologies.

Nathan Havill provided an "Introduction to evolutionary approaches to forest pest management" to highlight ways in which understanding micro-evolutionary and macro-evolutionary processes can inform management decisions. Phylogeny, divergence times, population genetic clustering, and biogeography reveal historical patterns that can inform current processes. Evolution can also be rapid and observed in the form of changes in allele frequencies, new lineage formation, and hybridization in response to human impacts on forest ecosystems. Examples included reconstructing the relationships among hemlock species, and hybridization between an introduced biological control agent and a native beetle species. These examples were used to show how this type of information is used to search for effective and safe ways to manage the impacts of the invasive hemlock woolly adelgid.

Matt Ayres spoke about "Evolutionary legacies, global change, and a new world of forest pestilence." He used examples from several forest pests systems to discuss how changes in climate, globalization, and land use interact to affect insect pestilence. The recent range expansion of southern pine beetle into the pinelands of New Jersey shows how climate change can permit epidemics of indigenous species in previously unimpacted forests. He pointed out that the concepts of introduction, establishment, and invasion employed by conservation biologists and forest managers have parallels with stable coexistence and niche theory from community ecology. The introduction of non-native invasive species also shows how natural enemies and host

resources interact with host resistance, host recognition, and competitors to determine patterns of forest pestilence. For example, *Tomicus piniperda* populations have apparently stabilized in North America at low non-damaging levels, while the emerald ash borer seems en route to decimating ash trees throughout North America. Whether tree species are native or introduced, and the community of natural enemies and their host ranges are additional evolutionary legacies that impact whether insect species will become pests.

Sara Gomez presented a talk titled "Attack by two invasive insects on eastern hemlock: ecological and evolutionary processes behind the interaction." When a tree species is attacked by multiple herbivores, the outcome is unpredictable, especially if they do not share a co-evolutionary history. This is the case with hemlock woolly adelgid and elongate hemlock scale which were introduced from Japan and have infested North American hemlocks. She summarized the effects of feeding by these insects on the availability and composition of amino acids in hemlock foliage. Adelgids, which form galls on their alternate hosts, may be manipulating their secondary hosts in a similar process as in gall formation. Adelgid feeding caused a dramatic increase in total amino acid concentration and also resulted in compositional changes with increased proportions of particular amino acids associated with water stress and senescence. Feeding by scale insects alone had only a slight effect while simultaneous attack by both species had more of an impact than the adelgid alone. In sequential treatments when adelgids were introduced first, there was less of an effect, suggesting that the sequence of colonization matters.

Finally, Enrico Bonello spoke about "Evolutionary approaches to understanding ash-emerald ash borer interactions." Since emerald ash borer is an introduced species in North America, it does not have an evolutionary history with native ash species. This has resulted in very little tree resistance and almost 100% tree mortality in all environments. A phylogeny of worldwide ash species showed that black ash is more closely related to resistant Manchurian ash than to green and white ash. This offers an opportunity to compare species with different co-evolutionary histories with the emerald ash borer but similar genetic backgrounds to examine whether there are molecular traits associated with resistance in Manchurian ash that could be inserted into the native species. Proteomic analyses found qualitative and quantitative differences between black and Manchurian ash that may be associated with resistance. He also described work using methyl jasmonate to simulate insect attack to examine induced resistance to ash borers.

Session 5 – Concurrent Session

Names Have Power: the Past, Present, and Future Classification of North American Bark Beetles and its Role in Designing Effective Management (Part 1)

Organizers: Brian Sullivan[1] and Anthony Cognato[2]

[1]USDA Forest Service, Southern Research Station, Pineville, LA; [2]Michigan State University, East Lansing, MI

The current species designations of North American bark beetles are based largely on adult morphological differences. However, a substantial body of recent molecular and biochemical studies has cast serious doubt on the validity of numerous morphologically-defined species

including ones in the important pest genera *Dendroctonus*, *Ips*, *Scolytus,* and *Xyleborus.* Can molecular data and phylogenetic analysis enlighten the recognition of bark beetle species, what are the potential consequences to revising bark beetle taxonomy based on phylogenetics, and will these changes enhance or confound management?

Systematics' Role in Designing Effective Management for Bark Beetles

Brian Sullivan

USDA Forest Service, Southern Research Station, Pineville, LA

{No abstract submitted.}

The Name IS the Game: Taxonomic Uncertainties, the Hobgoblins of Applied Entomology

Jim Labonte

Oregon Department of Agriculture, Salem, OR

{No abstract submitted.}

Reproductive Isolation and Genetic Differences among *Dendroctonus ponderosae* Populations: Why Does it Matter?

[1]Barbara Bentz and [2]Ryan Bracewell

[1]USDA Forest Service, Rocky Mountain Research Station, Logan, UT; [2]Department of Ecosystem and Conservation Sciences, University of Montana, Missoula, MT

Phenotypic plasticity in thermally-regulated traits enables close tracking of changing environmental conditions, and can thereby enhance the potential for rapid population increase, a hallmark of outbreak insect species. *Dendroctonus ponderosae* feed on *Pinus* species in diverse climatic regimes throughout western North America, and show eruptive population dynamics. We describe geographical patterns of plasticity in *D. ponderosae* development time and adult size by examining reaction norms of populations from multiple latitudes. We found significant genetic and phenotypic variation among populations. Reproductive incompatibilities were also found between *D. ponderosa* populations in a molecularly cryptic geographic zone between the states of Oregon and Idaho. We discuss the implications of speciation to understanding and managing this economically and ecologically important species.

The Need for Systematics for Detection and Identification of Non-Native Bark Beetles

Robert J. Rabaglia

USDA Forest Service, Forest Health Protection, Arlington, VA

There are more than 6,000 species of bark and ambrosia beetles (Curculionidae: Scolytinae) world-wide, and many are well documented as good invaders of new habitats. In the US, they are one of the most commonly intercepted families of insects, and between 1984 and 2008, there were more than 8,000 interceptions of cargo and commodities with scolytines. Many of the species that are intercepted and established in other areas are in genera that are very specious and difficult to identify to the species level. Since 2007, the Forest Service, Early Detection

and Rapid Response (EDRR) project has put up traps baited with bark beetle pheromones and karimones targeting these species in wooded areas at high risk locations. More than 300,000 specimens of scolytines have been screened and identified, and two species new to the US have been found (an additional five species new to the US were identified in the pilot phase of the EDRR project). For those identifying beetles from interceptions or domestic surveys, there is a need to quickly and accurately identify suspect specimens. Identifiers must be familiar with the non-native and native fauna. Keys to species and authoritatively indentified specimens of the commonly intercepted genera are often lacking. A good reference collection and well-illustrated keys to native species in an area are necessary for accurate and rapid identification.

Session 6 – Concurrent Session

Names Have Power: the Past, Present, and Future Classification of North American Bark Beetles and its Role in Designing Effective Management (Part 2)

Organizers: Brian Sullivan[1] and Anthony Cognato[2]

[1]USDA Forest Service, Southern Research Station, Pineville, LA; [2]Michigan State University, East Lansing, MI

Delimitation and Identification of Scolytine Species with DNA Data

Anthony Cognato

Michigan State University, Department of Entomology, East Lansing, MI

{No abstract submitted.}

Taxonomic Confusion among the North American Conifer-Feeding *Scolytus*

Sarah Smith

Michigan State University, Department of Entomology, East Lansing, MI

{No abstract submitted.}

Electronic Delivery of Taxonomic Information to End Users

Thomas Atkinson

Pest Management Research Inc., Austin, TX

{No abstract submitted.}

Session 7 – Concurrent Workshop

Invasive Wood Borers: What We Know and Don't Know

Organizer: Melissa K. Fierke

College of Environmental Science and Forestry, State University of New York, Syracuse, NY

Invasive wood borers are having tremendous ecological and economic impacts. Examples include emerald ash borer and the demise of millions of ash trees, *Sirex noctilio* with its potential

to severely impact southern pine plantations and western pine forests, Asian longhorned beetle, the target of an intense eradication effort for its potential to harm multiple trees species, and lastly the goldspotted oak borer aggressively attacking and killing oaks in southern California. This symposium will address the current state of knowledge and identify critical issues where future research should be directed.

Emerald Ash Borer: Biology, Detection, Management, and Ash Mortality

Therese M. Poland[1], Deborah G. McCullough [2], and Daniel A. Herms[3]

[1] USDA Forest Service, Northern Research Station, East Lansing, MI; [2] Departments of Entomology and Forestry, Michigan State University, East Lansing, MI; [3] Dept. of Entomology, The Ohio State University, Wooster, OH

Emerald ash borer (EAB), *Agrilus planipennis* Fairmaire (Coleoptera: Buprestidae), an invasive phloem-feeding beetle native to northeast Asia, has killed tens of millions of ash (*Fraxinus*) trees in infested areas of eastern North America. It was discovered in 2002 near Detroit, Michigan and very little was known about its biology or how to detect and manage it. Since then, considerable research has been conducted. We have found that girdled trees and the leaf and bark volatiles they emit are attractive to EAB. Artificial traps baited with host volatiles have been developed and are being used for detection surveys. Several insecticide products have been evaluated for controlling EAB. Emamectin benzoate (TREE-äge™), a trunk-injected product, has consistently provided the highest level of EAB control and is the only product tested that provides more than one year of control with a single application. Clusters of girdled trees to attract and retain beetles, girdled trap trees and artificial traps to survey the EAB population, systemic insecticide treatments, and ash tree inventory and health monitoring surveys have been incorporated into a multi-agency pilot study to determine if available management options could be used to SL.ow A.sh M.ortality (SLAM) at isolated outlier infestations of EAB in Michigan's Upper Peninsula. As new tools are developed they will be incorporated into this management program and similar approaches being implemented at other sites. Without management programs to reduce ash mortality, impacts of EAB on ash ecosystems can be profound. Ash tree (DBH >2.5cm) mortality exceeds 99% in infested forests studied in southeast Michigan. The ash seed bank in these infested stands is rapidly depleted as overstory trees die and ash regeneration has ceased. Extirpation of ash could impact numerous other species (286 arthopods use ash as a host), and create canopy gaps that may be colonized by invasive plants and influence the communities of ground beetles.

Sirex noctilio: Biology, Parasitism and Native Siricids

Melissa K. Fierke[1], Kamal Gandhi[2], Matthew Ayers[3]

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The European woodwasp, *Sirex noctilio* (Hymenoptera: Siricidae) is established in North America and may be a threat to economically important southern and western pine forests. It exhibits a rather unique life cycle where oviposition of a toxic mucus and a fungal symbiont, *Amylostereum areolatum*, is necessary for successful larval establishment. North American parasitoids include *Ibalia leucospoides ensiger*, *Rhyssa persuasoria*, *R. lineolata* and *Megarhyssa nortoni*. Ibalia are egg/small larvae parasitoids while the rhyssines parasitize larger larvae. A cleptoparasitoid, *Psue-*

Siricid image by Chris Standley

dorhyssa maculicoxis, has also been found and may limit parasitism associated with rhyssine parasitoids. Research over the last three years in New York has documented parasitism ranging from 17-31% and variable numbers of *S. noctilio*, parasitism and native siricids in *Pinus resinosa* and *P. sylvestris* from sampled stands. Preliminary phenologies of emergence indicate *S. noctilio* and native siricids overlap minimally and that the majority of *I. l. ensiger* parasitoids emerge in sync with *S. noctilio*. Research on host preferences of *S. noctilio* on southeastern pine species indicate females preferred to drill with their ovipositors on white, Scots, and Virginia cut pine logs, with the greatest emergence in these species as compared to shortleaf, slash, longleaf, and loblolly pines. A survey of native siricids in the southeastern region indicates that *Sirex* spp. were caught most frequently in traps baited with a *Sirex* lure. Both male and female *S. noctilio* exhibit extreme size variability ranging from ~9 mm to 37 mm and dissections revealed larger females carry more eggs. Percent parasitism of siricid larvae decreased as abundance of siricids increased. Evaluation of abundance of *S. noctilio* emergence from stands in central NY did not reveal spatial patterning. Overall, it appears that *S. noctilio* may have limited pestilence in the NE US, however, effects on southern and western pine forests are unknown. We also do not know how interspecific interactions will play out with native bark beetles, their mites and symbiotic fungi. There is much research to be done on the basic biology of this invader, e.g., sex ratio and size variability, toxic mucus, symbiotic fungus, as well as parasitism and interactions with native siricids and competition with other organisms occupying similar habitats.

Asian Longhorned Beetle: Biology, Detection, Eradication

Stephen A. Teale

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In its native range, ALB is a non-pest in *Acer* mono forests in Korea and severely damaging in monocultures of poplar and willow planted on arid sites in China. In North America, ALB is non-native, invasive and primarily confined to urban forests. The level of damage ALB would cause if it were to become established in rural forests is an important question that remains unanswered. Diameter-limit cutting is a common form of high-grading in the Northeast that, when applied to even-aged stands, results in a residual stand that is slower growing, less vigorous and genetically inferior. Thus, the assumption that rural forests may be more resistant to ALB is unsupported. The U.S. eradication program is based upon survey by visual inspection followed by the removal of infested and high-risk trees. Prophylactic treatment of trees with imidacloprid is also a significant component of the program. As of 2008, not including Massachusetts, over 8,543 infested and 33,595 high-risk trees have been removed in the U.S. The Worcester, MA quarantine zone is 166 km^2 and at least 16,390 infested trees and 10,250 high-risk were removed by 2009. As of August 2009, over 866,000 trees in the U.S. had been prophylactically treated with imidacloprid. This strategy has been successful in Illinois where ALB is considered eradicated. In Canada, ALB was discovered in Toronto in 2003. The Canadian Food Inspection Agency removed approximately 25,000 high-risk and infested trees. Annual surveys around the initial infested

area have detected no infested trees in 2008 of later. Challenges to eradication are numerous, but because the key to success is the location of every infested tree, efficient detection is paramount. Visual surveys were reported by APHIS to be 33 to 60 percent effective, depending upon the method of survey (ground, bucket-truck, or tree-climber) and there currently are no effective lures available to reliably attract ALB into traps. In the U.S., three groups are working on the development of attractants: (1) male pheromones + host volatiles (K. Hoover, M. Nehme, A. Zhang), (2) female pheromone + host volatiles (S. Teale, J. Wickham), and (3) host attractants from *Acer mono* (M. Smith). Traps with male pheromones have captured significantly more females than controls. Similarly, traps with female pheromones pheromones have captured significantly more males than controls. In the field, *A. mono* sentinel trees attracted adults in a sex ratio of 3.5:1 of females to males. Following the arrival of females, the sex ratio of attracted beetles falls to 2:1. Statistically significant trap captures have been achieved with male pheromones, female pheromones, and host volatiles, but there is still nothing like the gypsy moth pheromone for ALB.

Goldspotted Oak Borer: What We Still Don't Know about Biology, Detection, and Management

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The goldspotted oak borer, Agrilus auroguttatus (Coleoptera: Buprestidae), is a new pest to southern California oak woodlands. To gauge the threat of this new pest, forest stand conditions were assessed in its introduced region of southern California, its native region of southeastern Arizona, the native region of the sibling speciese, A. coxalis Waterhouse, in southern Mexico, and uninfested oak stands in southern California. The level of infestation and oak mortality was significantly higher in southern California than in the native regions of both Agrilus spp. Detection and control (insecticide treatments, sanitation) options are being developed into an integrated pest management plan for implementation at high-value sites on the expanding edges of the infestation.

Session 8 – Concurrent Session

Genetics of Bark Beetles and Associated Microorganisms

Organizers: Ken Raffa[1] and Barbara Bentz[2]

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Genetics is one of the most rapidly expanding fields in biology. Innovative techniques are continually being developed allowing insight into variation among organisms within and between species, phylogeography, and specific genes responsible for particular traits. Many of the devel-

oped methods are useful tools for studying population ecology, including potential adaptive response to changing conditions. In this workshop four presentations highlighted the innovative research currently being conducted that targets the use of genetic tools for understanding the ecology of eruptive bark beetle populations and their associated microorganisms.

Mountain Pine Beetle Genomics

Christopher I. Keeling

University of British Columbia, Michael Smith Laboratories, Vancouver, BC

The mountain pine beetle (MPB, *Dendroctonus ponderosae*) is devastating the pines in western North America, particularly in British Columbia, Canada. MPB has now entered new habitats and new hosts on the eastern side of the Rocky Mountains, and Canada's vast boreal forest is now at risk for widespread infestation by this beetle. To understand the interactions between the mountain pine beetle, its associated fungi, and the host pine trees, we have created extensive transcriptome and genome sequence resources for the MPB. These resources have allowed us to begin to examine the various processes of host colonization such as olfaction and pheromone biosynthesis at the molecular level. We have also obtained quantitative transcriptomic and proteomic data from specific tissues to guide the identification and functional characterization of genes such as cytochromes P450 and isoprenoid pathway genes involved in the processes of pheromone biosynthesis, and our progress to date will be described.

Insights into the Biology of the Mountain Pine Beetle (*Dendroctonus ponderosae*) through Transcriptome Sequencing

Mike Pfrender[1], Karen Mock[2] and Barbara Bentz[3]

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{No abstract submitted.}

Mountain Pine Beetle System Genomics: Spatial Genetic Structure of the Mountain Pine Beetle Outbreak in Western Canada

Brent W. Murray[1], N. Gayathri Samarasekera[1], Nicholas V. Bartell[1], Yisu Li[2], B. Staffan Lindgren[1], Felix Sperling[2], Janice E.K. Cooke[2], Corey S. Davis[2], Patrick M.A. James[2], David W. Coltman[2] and Karen E. Mock[3]

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The mountain pine beetle, (*Dendroctonus ponderosae*), is currently causing an epidemic of record size in Western Canada. Tree mortality, mostly lodgepole pine (*Pinus contorta*), has occurred over 16 million hectares of forest. Spatial genetic information can be used to infer current dispersal patterns, long-term phylogeographic processes and to study adaptive changes. Infor-

mation on "neutral" microsatellite variation in beetles from 49 sampling locations throughout BC and AB shows a North-South population structure that is supported by Bayesian structure analysis, North-South genetic relationships and diversity gradients, and the lack of isolation-by-distance in the northernmost cluster. Our findings are consistent with spatiotemporal analyses of the current epidemic that supports a multi-center hypothesis. Northern outbreaks are consistent with an expansion out of the Chilcotin plateau while southern outbreaks are consistent with multiple centers of origin. Suites of gene-linked have been developed to study adaptive changes. A preliminary analysis of gene-linked microsatellites shows a strong signature of selection at an Apoptosis Inhibitor Protein. A panel of 1538 coding regions SNP's has been developed to further study adaptive changes in mountain pine beetles.

Grosmania clavigera Genome, Physiology and Ecology: What We have Learned About the Diversity of this Bark Beetle Associate and Pine Pathogen

Colette Breuil

Department of Wood Science, University of British Columbia, BC

{No abstract submitted}

Session 9 - Plenary Session

30-Plus Years of Research on Tree Defense Mechanisms: Now What?

(continued as Concurrent Session 10)

Organizers: Nadir Erbilgin[1], Enrico Bonello[2], and Paal Krokene[3]

[1]Department of Renewable Resources, University of Alberta, Edmonton, AB; [2]Department of Plant Pathology, The Ohio State University, Columbus, OH; [3]Norwegian Forest and Landscape Institute, Ås, Norway

As the bulk of energy supporting organisms in food webs comes from the autotrophic action of green plants, it should not be surprising that one of the most prominent sets of adaptations in the history of life is plant defence against natural enemies. Natural history of plant defence and its importance in mediating community interactions has led to a vast diversity of research in plant defenses. Our knowledge about plant defense mechanisms has increased for the last 30+ years. Research covers topics from identification of (candidate) genes to understanding role of environment and other organisms in complex plant-insect-pathogen interactions.

In agriculture, the discovery of natural or synthetic hormones inducing resistance in plants has prompted a strong interest in "Induced Resistance" as a strategy for crop protection. We posed the following question: Can we achieve a similar success story in forestry? We believe we can achieve such success story. For example, integration of ecological, behavioral, genomic and metabolomic tools can characterize important defense traits, and these traits can be used for selecting resistant trees in breeding programs.

We summarized several important studies from 1970's to 2000's and stated that 1990's was the turning point in plant defense studies in forestry.

Genetics, Environment, and G x E Effects on Chemical Defenses in *Populus*

Richard L. Lindroth

University of Wisconsin-Madison, Madison, WI

The genus *Populus* comprises high-value commercial species/hybrids as well as quintessential "foundation species" in managed and natural forest ecosystems. The evolutionary and ecological success of this genus is intimately linked to its secondary chemistry, principally salicylate phenolic glycosides and condensed tannins.

Poplar species exhibit striking phenotypic variation in secondary chemistry; foliar levels of the dominant constituents range from 1 to 20% leaf dry weight. This variation is due primarily to genetic and environmental factors, and interactions among them. Levels of phenolic glycosides are strongly genetically canalized, exhibiting striking variation among genotypes but generally little variation in response to abiotic (e.g., resource availability) and biotic (e.g., defoliation) factors. Levels of condensed tannins, however, vary strongly in response to genetics, environment, and their interaction. Allocation to production of phenolic glycosides and tannins exacts a cost to growth in aspen (*Populus tremuloides*), especially in seedling, sapling and pole-stage trees. Costs themselves are environmentally influenced, with greater costs incurred in resource (light, nutrients) deficient environments.

G, E, and G x E effects on *Populus* chemistry mediate trophic interactions, influence herbivore and soil microbial community composition, and govern ecosystem dynamics. At moderate to high concentrations, phenolic glycosides confer defense against specialist and generalist insects and browsing mammals. They influence rates of defoliation in experimental aspen stands and structure communities of insects in riparian cottonwood stands. They modify soil microbial communities and function and regulate rates of litter decomposition. Thus, clonal reproduction of some *Populus* species, coupled with genetic differences in secondary chemistry, contribute to a geographic mosaic of community assemblage and ecosystem function at the landscape level.

Populus has emerged as a major woody biofuel feedstock in the northern hemisphere. Numerous efforts worldwide are exploring means to alter poplar growth and composition, via traditional breeding as well as engineered genetic modifications. Our work with natural *Populus* systems cautions that to be successful, efforts to produce genetic strains of poplar for specific uses must consider the potential for G x E and pleiotropic effects to alter the expression of chemical defenses, and thus influence a host of ecological interactions.

Lindroth, RL; S-Y Hwang. 1996. Diversity, redundancy and multiplicity in chemical defense systems of aspen. Pp. 25-56, in Phytochemical Diversity and Redundancy in Ecological Interactions. (Romeo, JT; Saunders, JA; Barbosa, P. eds.) Recent Advances in Phytochemistry, Vol. 30. Plenum Press, New York, NY.

Schweitzer, JA; Madritch MD; Bailey, JK; LeRoy, CJ; Fischer, DJ; Rehill, BJ; Lindroth, RL; Hagerman, AE; Wooley, SC; Hart, SC; Whitham, TG. 2008. From genes to ecosystems: the genetic basis of condensed tannins and their role in nutrient regulation in a *Populus* model system. Ecosystems 11:1005-1020.

Resource Allocation in Tree Defense: Scaling from Molecules to Whole Plant

Daniel A. Herms

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{No abstract submitted.}

Deploying Resistance: Current Practice, Results, and Future Opportunities

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Forest trees in natural ecosystems, planted forests, and urban plantings are subject to serious damage or mortality by an array of biotic organisms or abiotic events. Natural occurring genetic resistance in an active, selection and breeding program represents the key and sometimes only method for retaining some trees species as healthy components in our natural or planted forests. It also has the advantage that it is a natural 'green' path to implement with little or no negative 'side-effect' consequences. Resistance programs in some forest tree species have been ongoing for >50 years. Notable examples include programs for white pine blister rust, Dutch elm disease and chestnut blight (Sniezko 2006) and fusiform rust resistance. The Sitka spruce program for weevil resistance provides a dramatic example of a program that has captured insect resistance (King and Alfaro 2009). Knowledge of the pattern of susceptibility and resistance over the landscape provides options for establishing economically viable plantations and urban plantings, as well as restorative plantings. A newer applied concept uses the knowledge and availability of resistance in innovative proactive restoration plantings or management strategies (Schoettle and Sniezko 2007).

Some types of resistance are useable immediately; others may need breeding to increase the overall resistance. The use of resistant seed provides a very beneficial management tool for maintaining the health of our forest ecosystems, as well as in commercial and urban plantings. Continued monitoring and research, as well as support for operational programs is needed to evaluate the durability of resistance, refine site hazard information, develop other management tools to complement resistant stock, fast-track the development and utilization of higher levels (or combinations) of resistance in existing and future programs.

King, J.N.; Alfaro, R.I. 2009. Developing Sitka spruce populations for resistance to the white pine weevil: summary of research and breeding program. B.C. Ministry of Forests and Range, Research Branch. Technical Report 050.

Schoettle A.W., and Sniezko R.A. 2007. Proactive intervention to sustain high elevation pine ecosystems threatened by white pine blister rust. Journal of Forest Research. 12:327-336.

Sniezko R.A. 2006. Resistance breeding against nonnative pathogens in forest trees — current successes in North America. Canadian Journal of Plant Pathology. 28: S270–S279.

Session 10 – Concurrent Session

Thirty-Plus Years of Research on Tree Defense Mechanisms: Now What?

(continuation of Plenary Session 9)

Organizers: Nadir Erbilgin[1], Enrico Bonello[2], and Paal Krokene[3]

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Genomics of Induced Defense in Poplar: Complexity and Functionality

C. Peter Constabel

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In response to damage by leaf-eating and other herbivorous insects, hybrid poplar saplings (*Populus trichocarpa x deltoides*) respond with dramatic shifts in foliar gene expression leading to enhanced expression of defense-related genes. Following our work on the identification of induced poplar defense genes, our work is now focused on the biochemical and physiological characterization of these genes, and their role in defense. For example, having cloned several genes encoding induced Kunitz trypsin inhibitors, we subsequently produced recombinant trypsin inhibitor protein for each of five inhibitor protein isoforms. This allowed us to demonstrate that these proteins do in fact inhibit digestive proteases from both mammals and insects (Major and Constabel, 2008). Furthermore, each recombinant protein has a unique activity profile, suggesting specialization against different pests or proteases. In work using transgenic defense-gene overexpressing poplar plants, we demonstrated the efficacy of peroxidase overexpression in poplar defense against white-marked tussock moth *Orygia leucostigma* and gypsy moth (*Lymantria dispar)*. Interestingly, this only occurred when plants were also wounded prior to analysis, suggesting that induction of H_2O_2 or other cofactors was required (Barbehenn et al. 2010). In another suite of transgenics, we were able to demonstrate that transgenic overexpression of a MYB transcription factor leads to poplar plants with greatly enhanced condensed tannin accumulation (Mellway et al. 2009). However, analysis of these plants and experiments with forest tent caterpillar (*Malacosoma disstria*) found no deterrent effect of condensed tannins on these forest tree defoliators. Based on this series of experiments, we suggest that functional analysis of defense genes is essential in order to further understand the complexity of defense responses in trees.

Major, I.T., and Constabel, C.P. 2008. Functional analysis of the Kunitz trypsin inhibitor family in poplar reveals biochemical diversity and multiplicity in defense against herbivores. *Plant Physiology* 246: 888-903

Mellway, R.D., Tran, L.T., Prouse, M.B., Campbell, M.M., and Constabel, C.P. 2009. The wound-, pathogen-, and UV-B -responsive *MYB134* gene encodes an R2R3 MYB transcription factor that regulates proanthocyanidin synthesis in poplar. *Plant Physiology* 150: 924-941.

Barbehenn, R.V., Dukatz, C., Holt, C., Reese, C., Martiskainen, O., Salminen, J.-P., Yip, L., Tran, L., Constabel, C.P. 2010. Feeding on poplar leaves by caterpillars potentiates foliar peroxidase action in their guts and increases plant resistance. *Oecologia* 164: 993-1004.

Evidence for the Natural Occurrence of Systemic Induced Resistance in Populations of *Pinus radiata*

Tom Gordon

Department of Plant Pathology, University of California, Davis, CA

Studies conducted under controlled conditions document that systemic induced resistance (SIR) to pitch canker, caused by *Fusarium circinatum*, occurs in *Pinus radiata* (Monterey pine). The observation of disease remission in trees that had been severely affected by pitch canker suggested that SIR was operative in natural populations. That formerly susceptible trees had become resistant to pitch canker was confirmed through inoculations, which showed trees in remission

to sustain only very limited lesion development. In a separate study, trees were found to be more resistant to pitch canker in areas where the disease was of long residence, as compared to trees in areas where the disease was only recently established. These observations may indicate that susceptibility to a disease is influenced as much by the history of exposure to a pathogen as by inherent genetic resistance.

Phenolic Compounds – Multiple Functions and Consequences for Landscape Ecology

Johanna Witzell

Swedish University of Agricultural Sciences, Alnarp, Sweden

The functions of phenolics in the interactions between trees, their natural enemies and abiotic environment have been actively investigated during the last 30 years. Results from several studies with different systems and at different scales emphasize the pronounced variation in tree phenolics, apparently reflecting their multiple functions and complex regulation (Gripenberg et al. 2007; Stolter et al. 2010; Witzell & Martín 2008). It may therefore be justified to consider the high variation in these chemicals as a defensive mechanism in itself and accordingly revise the priorities in studies on phenolics, in tree breeding, and in landscape management. A novel functional layer contributing to the spatial and temporal variation in phenolics may be endophytic microfungi that spread to trees horizontally, from the surrounding landscape. Endophytes may induce alterations in the phenolic status of trees (White and Torres 2010), adding to the variation that renders individual trees and forest landscape into an uncertain resource for natural enemies. Recent advances in high-throughput methods ("omics") have opened up new possibilities to gain information about the responses of the phenolic pool as an integrated part of the plant's metabolism. However, we are still limited by the point-in time analysis, which only provides us with snap-shots of the dynamic phenolic metabolism of trees. NIRS (near-infrared spectroscopy) has been suggested as a promising method to scan the chemical status of trees at large scale and further development of this method and other potential chemical imaging methods remains as a challenging task for the future. Equally important will also be to downscale the analysis to the level of single cells, e.g. using micro- or nanotechnologies, or in order to better understand the basic mechanisms of phenolic metabolism.

Gripenberg, S; Salminen, J-P; Roslin, T 2007. A tree in the eyes of a moth – temporal variation in oak leaf quality and leaf-miner performance. Oikos 116: 592-600.

Stolter, C; Ball, JP; Niemela, P; Julkunen-Tiitto, R 2010. Herbivores and variation in the composition of specific phenolics of boreal coniferous trees: a search for patterns. Chemoecology 20(4):229–242.

White Jr, JF; Torres, MS 2010. Is plant endophyte-mediated defensive mutualism the result of oxidative stress protection? Physiologia Plantarum 138(4):440-446.

Witzell, J; Martín, JA 2008. Phenolic metabolites in the resistance of northern forest trees to pathogens — past experiences and future prospects. Canadian Journal of Forest Research 38: 2711–2727.

The Carbon Starvation Hypothesis: Relationship to Host Defense Theory

M. Gaylord[1], T. Kolb[1], N. McDowell[2], and W. Pockman[3]

[1]School of Forestry, Northern Arizona University, Flagstaff, AZ; [2]Earth and Environmental Sciences Division, Los Alamos National Laboratory, Los Alamos, NM; [3]Department of Biology, University of New Mexico, Albuquerque, NM

Regional-scale tree mortality after drought is a common occurrence; however, isolating the mechanism of tree mortality is still challenging. One explanation for the pulse of piñon pine (*Pinus edulis*) mortality that occurred after the 2002 drought in the southwestern USA is provided by the carbon starvation hypothesis (CSH), which incorporates the Growth Differentiation Balance Hypothesis (GDBH), (McDowell et al. 2008, Herms and Mattson 1992). This hypothesis posits that drought depletes carbon reserves because carbon assimilation is less than carbon use, which in turn reduces carbon allocation to resin defenses and consequently predisposes trees to mortality from insect attack. Our objectives were to quantify bark beetle resistance, i.e. resin flow, of piñon at an experimental drought study started in 2007 at the Sevilleta LTER in central New Mexico. The study includes four 40 x 40 m treatment plots replicated in three blocks. Treatments consist of ambient (A), removal of 50% ambient annual precipitation (H_2O-), irrigation to produce 150% addition of ambient annual precipitation (H_2O+), and an infrastructure control (CC) that measures the impact of precipitation removal/addition equipment without changing the annual amount. Our hypothesis (based on the GDBH and CSH) was that piñon resin volume, measured over a 24-hour period post bole wounding, would decline in the H_2O- treatment relative to the A, C and H_2O+ treatments. Resin volume was measured once pretreatment (2007) and over three post-treatment years (2008-2010). Post-treatment resin volume on the H_2O- plots was significantly lower ($P = 0.0489$) than resin volume on the H_2O+ plots, but did not differ from other treatments. Analysis of $d^{13}C$ indicates that the resin was not from recently assimilated carbon, and suggests that resin was formed and stored over long periods. These isotope results may explain why differences in resin flow were barely significant even 3 years post-treatment. By August 2010, 24% of the study trees had died and showed evidence of attacks from bark/twig beetles; 72% of these trees were located in the H_2O- treatment. This result suggests that the experimental drought predisposed trees to insect attacks. We suspect that unexamined factors, such as induced defenses, resin chemistry, and/or tree volatiles, also may explain the higher susceptibility of drought-stressed trees to bark beetle attacks. We also are investigating the relationship between piñon response to drought and carbon allocation to resin ducts, such as size and density in sapwood (Kane and Kolb 2010).

Herms DA, Mattson WJ. 1992. The dilemma of plants: to grow or defend. Quarterly Review of Biology 67: 282-335.

Kane JM, Kolb TE. 2010. Importance of resin ducts in reducing ponderosa pine mortality from bark beetle attack. Oecologia 164: 601-609

McDowell N, Pockman WT, Allen CD, Breshears DD, Cobb N, Kolb T, Plaut J, Sperry J, West A, Williams DG, Yepez EA. 2008. Mechanisms of plant survivial and mortality during drought: why do some plants survive while others succumb to drought? Tansley review, New Phytologist 178:719–739.

Session 11 – Concurrent Session

Insects in Forest Landscapes: Causes and Consequences of Insect Outbreaks

Organizers: Robert N. Coulson[1] and Frederick M. Stephen[2]

[1]Knowledge Engineering Laboratory, Department of Entomology, Texas A&M University, College Station, TX; [2]Department of Entomology, University of Arkansas, Fayetteville, AR

Insect outbreaks are disturbance events that serve as initiating causes for change in forest landscape structure and function. The effects (consequences) of insect outbreaks can be inter-

preted from different landscape ecological perspectives. In this workshop we examine insect/forest interactions in the context a suite of contemporary topics in landscape ecology: effects of landscape connectivity on forest insect outbreaks, trophic cascades resulting from insect outbreaks, effects of insect outbreaks on carbon sequestration, effects of disturbance events on ecological succession, etc. The specific forest landscape/insect systems include: gypsy moth and eastern deciduous forests, mountain pine beetle in white bark and lodge pole pine forests, red-oak borer and oak forests, emerald ash borer and northern hardwood forests, and southern pine beetle and southern yellow pine forests.

The Forest Landscape Insect Interaction Perspective

Robert N. Coulson[1] and Frederick M. Stephen[2]

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{No abstract submitted.}

Climate/Beetle Disruption of Adaptive Disturbance Regimes in Whitebark Pine

Jesse Logan

USDA Forest Service (retired), Logan, UT

{No abstract submitted.}

Forest Insect Outbreaks and Carbon Dynamics

Allan Carroll[1] and Werner Kurz[2]

[1]University of British Columbia, Vancouver, BC; [2]Natural Resources Canada, Pacific Forestry Centre, Victoria, BC

{No abstract submitted.}

Gypsy Moth to Insect Invaders of the Northeast

Andrew Liebhold

USDA Forest Service, Northern Research Station, Morgantown, WV

{No abstract submitted.}

Causes and Consequences of a Red Oak Borer Outbreak in the Mountains of Arkansas

Fred Stephen[1], M. K. Fierke[2], L. J. Haavik[3], and J. J. Riggins[4]

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{No abstract submitted.}

Impacts of Emerald Ash Borer in the Great Lakes Region

Andrew Storer

Michigan Technological University, Houghton, MI

{No abstract submitted.}

Herbivory and the Hemlock Woolly Adelgid: What Happens when the Hemlocks are Gone?

Robert Coulson[1], Yu Zeng, A. Birt, M. Tchakerian, C. Lafon, D. Cairns, J. Waldron, and D. Street

[1]Knowledge Engineering Laboratory, Department of Entomology, Texas A&M University, College Station, TX

{No abstract submitted.}

Session 12 – Concurrent Session

How's your Aspen? Patterns of Dieback and Decline in Western North America

Organizer: Robbie W. Flowers

Oregon Department of Forestry, Salem, OR

Quaking aspen (*Populus tremuloides*) is the most widespread tree species in North America. It occurs in a wide variety of environments and provides important landscape diversity, wildlife habitat, riparian protection, and aesthetic values. Recent increases in overstory aspen decline and mortality, along with reduced regeneration, have been reported in many areas. The sudden onset and synchronicity of this phenomenon stands in contrast to more typically-observed mortality processes. In this workshop, presenters will describe the factors that appear to be driving this trend in western North America. Open-discussion will follow with participants invited to share brief updates on aspen conditions in their area.

Damage Agents and Condition of Mature Aspen Stands in Montana and Northern Idaho

Brytten E. Steed[1] and Holly S. J. Kearns[2]

[1]USDA Forest Service, Northern Region, Forest Health Protection, Missoula, MT; [2]USDA Forest Service, Northern Region, Forest Health Protection, Coeur d'Alene, ID

Forest, range, and wildlife managers in the Interior West of the US have documented a decline in total forest acreage and health of aspen forests since the 1970's. Insects and diseases are often notable, but play a largely undefined role in aspen mortality. To assess mortality levels and damaging agent activities we established 76 permanent plots in mature aspen stands in Montana and northern Idaho. Plots were randomly placed but had to meet the minimum criteria of having at least seven live stems ≥5" dbh within a 1/20th acre plot. A total of 1,423 aspen stems 2.0-24.2" dbh, as well as many regeneration sprouts, were evaluated. More than 55 damaging agents were recorded with insects, diseases, and abiotic forces all appearing as important damaging agents on mature stems and sprouts. However, conifer competition and grazing on regeneration were noted on 88% and 75% of plots, respectively, and are considered important factors negatively impacting aspen stand health. Based on low tree mortality (7% average, 29% plot maximum), and a healthy distribution of size classes, our plots do not appear to suffer from sudden aspen decline (SAD).

Steed, B.E.; Kearns, S.J. 2010. Damage agents and condition of mature aspen stands in Montana and northern Idaho. Numbered Report 10-30. USDA Forest Service, Forest Health Protection, Missoula, MT. 26 p.

Sudden Aspen Decline: Symptoms, Consequences, and Future Projections

Sheryl L. Costello[1], James J. Worrall[2], and Suzanne B. Marchetti[2]

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Sudden aspen decline (SAD), characterized by rapid, synchronous branch dieback and mortality on a landscape scale, has been occurring in aspen (*Populus tremuloides)* in Colorado since 2004. Worrall et al. (2008 and 2010) have found that SAD is not associated with stand age in overstory trees or due to a primary pathogen, but rather results from a number of factors including climate change. Aspen stands experiencing the highest levels of mortality occurred at low elevations, on south/west slopes, in upper slope positions, at low site indices, and in dry vegetation types. These stand conditions combined with a severe drought in 2002 allowed such contributing factors as *Cytospora* canker, bronze poplar borer, and aspen bark beetles to cause tree mortality. If additional drought and warming occurs as predicted under climate change models, the areas suitable for aspen growth will be at higher elevations than are currently suitable. Using Rehfeldt (2009) models, Worrall et al. (unpublished) found that by 2090 the lower elevation suitable for aspen could be 2,500 feet higher than in 1990. Currently, drought conditions in Colorado have abated and some previously stressed aspen stands appear to have revitalized. However, future climate conditions will no doubt place additional stress on these and other aspen stands. Additional research is being conducted in Colorado and Wyoming by K. Burns, W. Jacobi, J. Blodgett, and others with results forthcoming in the near future.

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Worrall J.J.; Egeland L.; Eager T.; Mask R.A.; Johnson E.W.; Kemp P.A.; Shepperd W.D. 2008. Rapid mortality of *Populus tremuloides* in southwestern Colorado, USA. Forest Ecol. Manag. 255: 686-696.

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Evaluating Aspen Damage and Decline in the Pacific Northwest

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This study focused on assessing the current stand conditions and primary damaging agents affecting aspen in the Pacific Northwest (PNW) by ground-based sampling of areas identified in annual forest health aerial detection surveys (ADS). Forty-eight sites dominated by quaking aspen (*Populus tremuloides*) were evaluated in Oregon and Washington in 2010. Stand and site attributes, aspen regeneration, and the major damaging agents were recorded at representative plots. Preliminary observations indicate that 67% of stands were "stable", while 33% showed symptoms consistent with slow decline. Conifer competition was common and recorded in 63% of plots. Standing mortality of aspen stems (≥5" dbh) ranged from 0 - 88% of total basal area, with the majority of stands having <33%. Aspen regeneration (<5" dbh) was detected in 94% of plots, but only 42% of plots had advanced regeneration present. Ungulate damage, stem cankers, stem decays, and stem insects were the most common agents affecting live trees,

while ungulate feeding, foliage diseases, and defoliating insects were most frequently observed impacting aspen regeneration. Additional surveys and assessments are planned at existing and new sites in 2011, and will assist in providing a broader assessment of aspen damage in the PNW as well as inform regional ADS coding.

Quaking Aspen Decline in Oregon: Biotic and Abiotic Factors

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Quaking aspen (*Populus tremuloides*) is one of the few deciduous trees in the arid western US, and there has been much concern about its persistence. Recently, there has been an emphasis on the role that insects and diseases play in aspen stand disturbance, especially in the face of climate disruption. I suggest a temporal approach to aspen stand dynamics. Key biotic factors (herbivory, conifer encroachment) and abiotic factors (soil, moisture, disturbance, biophysical setting) affect aspen establishment and recruitment across time. My previous research in Oregon found that aspen sprout density and height were driven by conifer encroachment and herbivory, respectively. These factors affected long-term stand dynamics, leaving some stands with no understory, or cohorts younger than 40 years, and predisposing them to overstory loss. My current research is looking at the role that moisture and disturbance play in aspen stand dynamics in the inland PNW. Release events, such as fire and conifer removal, may decrease moisture stress and allow aspen stands to persist in the face of climate disruption. As such, I offer that current aspen stand dynamics and the loss of overstory to insects and diseases should be put into the context of sprouting and overstory recruitment in the last 50-80 years.

Session 13 – Concurrent Session

Interactions Between Ecosystem Disturbances and Forest Insects

Organizers: Kamal J.K. Gandhi[1], Barbara Bentz[2], and Kenneth F. Raffa[3]

[1]University of Georgia, Athens, GA;[2]USDA Forest Service, Rocky Mountain Research Station, Logan, UT;[3]Department of Entomology, University of Wisconsin, Madison, WI

Natural disturbances such as windstorms, wildfires, and insects are important in the functioning and structure of forest ecosystems. Disturbances also pose management challenges, because insect populations may increase in numbers, and conversely, insect outbreaks may foster subsequent disturbances. Although such interactions are used as a basis for intensified control, empirical data to justify various management responses are often lacking. This workshop aims to address some of these questions, and to better understand patterns and processes stemming from natural disturbances.

Interactions Between a Catastrophic Wind-Disturbance Event, Subsequent Fuel-Reduction Activities, and Insects in Sub-Boreal Minnesota

K.J.K. Gandhi[1], D.W. Gilmore, R.A. Haack[2], S.A. Katovich, S.J. Krauth, W.J. Mattson[3], J.C. Zasada, and S.J. Seybold[4]

[1]University of Georgia, Athens, GA; [2]USDA Forest Service, Northern Research Station, East Lansing, MI; [3]USDA Forest Service, Institute for Applied Ecosystem Studies, Rhinelander, WI; [4]USDA Forest Service, Pacific Southwest Research Station, Davis, CA

We studied responses of sub-boreal forest insects to the 4th July, 1999 severe windstorm, and salvaging and prescribed burning in Minnesota. Major trends observed from ~130,000 individuals and >200 species of ground beetles and subcortical insects were: 1) salvaging and burning altered populations and communities of forest insects; 2) burning resulted in increased invasion by exotic ground beetles and greater populations of subcortical insects; 3) burning maintained fire-adapted ground beetles; 4) subcortical insects in the wind-disturbed sub-boreal forests declined naturally without the use of fuel-reduction activities; and 5) > half of the residual jack pine trees died in the wind-disturbed areas, and a woodboring beetle became a primary colonizer of jack pines.

Does Wildfire Promote Outbreaks by Tree-Killing Bark Beetles

K. Raffa[1], B. Bentz[2], D. Blackford[3], A. Lerch[1], E. Powell[1], and P. Townsend

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We studied the interactions and their mechanisms between wildfires and incidence of mountain pine beetle (MPB) outbreak in western forests. Two studies were conducted in UT and WY for four years in burned and unburned lodgepole and ponderosa pine forests that had endemic and epidemic populations of MPB. Fire injury weakened host defenses, especially their inducible defenses. MPB preferentially attacked fire-injured trees, but in a non-linear fashion: moderately injured trees were most commonly attacked. In contrast, severely burned trees have impaired defenses, but had more interspecific competitors and lower substrate quality. In lodgepole pine, MPB initially killed moderately injured trees, but then progressed onto healthy trees, suggesting the potential for outbreak. However, rates of attack failure likewise increased, and the populations declined. In ponderosa pine, beetles did not switch to healthy trees.

The Influence of Mountain Pine Beetle Outbreaks on Carbon and Nitrogen Dynamics in Lodgepole Pine Ecosystems

E.M. Hansen, M.C. Amacher, M.A. White, H.V. Miegroet, J.N. Long, and M.G. Ryan

We investigated C and N dynamics in lodgepole pine forests, with and without MPB disturbances. Results indicate total system C is slightly diminished following MPB disturbance but recovers to pre-outbreak levels after several decades, albeit with C amounts differing among compartments. MPB outbreaks have very little effect on soil or forest floor C. N pools are dominated by forest floor and soil compartments and are resilient to MPB disturbance. FVS simulations suggest that a cycle of repeated MPB disturbance can result in increased C uptake over a span of >100 years compared to a chronosequence of no disturbance. Total C storage, however, is generally greater among uninfested stands. Ecologically, MPB outbreaks release the energy and nutrients stored in overstory trees that have passed their maximal productivity.

Session 14 – Concurrent Session

Native Invasive Bark Beetles: Consequences of Range Expansion

Organizers: B. Staffan Lindgren[1] and Daniel A. Herms[2]

[1]Ecosystem Science and Management Program, University of Northern BC, Prince George, BC; [2]Department of Entomology, The Ohio State University, Ohio Agricultural Research and Development Center, Wooster, OH

Unsuitable climatic conditions are frequently a primary cause for range limits of herbivorous insects. Host tree populations outside of the historic range of a herbivore may not have evolved effective defenses. As a result of climate change, range expansion may provide native herbivores with 'defense-free' or 'defense-reduced' space in the form of naïve or new hosts, leading to unforeseen population dynamics, similar to what is often seen with exotic invasive insects. In this session, we discussed the theory behind this phenomenon, and presented evidence of where this may have happened with bark beetles, specifically the mountain pine beetle.

After a brief introduction to the session by Staffan Lindgren, Dan Herms gave a brief overview of the concept of "defense-free" space as a somewhat overlooked concept that may explain the establishment and severity of many 'intimate' herbivores, e.g., wood borers, phloem feeders, some sucking insects like scales and woolly adelgids. Some of these feeding guilds are bottom-up regulated, i.e., by host availability rather than top-down regulated by natural enemies. A second overview paper was presented by Allan Carroll (University of British Columbia, Vancouver, BC), who described how climatic changes may interact with other factors to affect various types of native, eruptive bark beetles. For herbivores with a climate-limited range, a shift in climate may allow a range expansion resulting in access to previously inaccessible hosts, or even novel hosts. The consequences may be the same in that they will encounter host populations that have not evolved effective defenses against the herbivore, leading to accelerated reproduction of the herbivore, and resulting in a population eruption.

The second part of the session consisted of two brief presentations on how the mountain pine beetle has responded to climate change at the edge of its historic range. Staffan Lindgren (co-authored by Niklas Björklund, Allan Carroll and Timothy Cudmore) described the results from Tim's graduate work showing an example of increased realized reproductive potential in mountain pine beetle when accessing defensively naïve lodgepole pine in historically climatically unsuitable areas. Erin Clark (University of Northern British Columbia; co-authored by Allan Carroll and Dezene Huber) then described how lodgepole pine in historically climatically unsuitable areas differ significantly both in terms of constitutive and induced monoterpene defenses, providing a potential mechanistic explanation for the accelerated population growth described by Staffan.

The final two papers described consequences of mountain pine beetle accessing novel host species. Nadir Erbilgin (University of Alberta; co-authored by Inka Lusebrink and Maya Evenden) reported on the results of a number of experiments involving lodgepole, jack pine and their hybrids investigating their responses to attack by mountain pine beetles. They found that jack pine releases similar monoterpene compounds as lodgepole pine, suggesting that jack pine can be as attractive as lodgepole pine. However they differ in their relationship with drought. Jack

pine seems to be resistant to drought than lodgepole pine, which agrees with the natural range of jack pine in boreal forest where jack pine can survive in dry habitats. Appropriately, Jesse Logan (USDA Forest Service (retired), Logan, UT), who predicted the mountain pine beetle range expansion into boreal jack pine forests long before it actually happened, gave the final presentation on how whitebark pine now faces severe pressure from mountain pine beetle outbreaks at ever higher elevation. He emphasized that expansion and contraction of the elevational range has occurred in the past, but in some areas whitebark pine has nowhere to go.

The session ended with a broader discussion of the potential for range expansion and subsequent eruptions in different feeding guilds. Insects mentioned were bronze birch borer, which has a climatic range limit to the north, and western conifer seed bug, which has become a serious pest of stone pine after its accidental introduction in Europe.

Session 15 – Concurrent Session

Walnut Twig Beetle and Thousand Cankers Disease: Framing the Response a Serious Threat to our Valuable North American Walnut Resource

Organizer: Steven J. Seybold

USDA Forest Service, Pacific Southwest Research Station, Davis, CA

The walnut twig beetle (WTB), *Pityophthorus juglandis* Blackman, is a native phloeophagous insect that has recently been associated with the newly described fungus, *Geosmithia morbida*. This insect-fungal complex, also known as thousand cankers disease (TCD), is fatal to walnut trees and is responsible for the gradual decline of several species of black walnuts in the western United States over the past decade. The disease was detected in Knoxville, TN in July 2010.

TCD poses a serious threat to native and introduced walnut species across the United States. Walnut trees are integral to natural forest ecosystems, favored as ornamentals, valued for timber (e.g., black walnut, *Juglans nigra*), and harvested for their nuts (e.g., English or Persian walnut, *J. regia*). The disease is potentially devastating to California's two endemic species, one of which (*J. californica*) is considered a threatened species because of its limited distribution. Because most orchard trees are grafted onto native black or hybrid black x English (Paradox) walnut rootstock, TCD also threatens the California walnut industry, whose production has had an annual value ranging from $558-$751 million between 2006 and 2009 (USDA National Agricultural Statistics Service, September 2010).

This workshop will explore the current status and anticipated impact of TCD in North America and will assemble the contributions of entomologists, plant pathologists, and a plant scientist from both a biological and administrative perspective. The outcome of the workshop will be a deeper understanding of our management approach to walnut timber and mast production in North America in the context of this new and threatening disease.

Introduction

Steven J. Seybold

USDA Forest Service, Pacific Southwest Research Station, Davis, CA

Moderator Seybold introduced the topic of thousand cankers disease (TCD) as an interaction between an insect vector (the walnut twig beetle, *Pityophthorus juglandis*), a fungal pathogen (*Geosmithia morbida*), and a host tree (*Juglans* sp.). He noted that the purpose of the workshop was to review research, outreach, and administrative activity on this disease over the last three years and to look ahead to the next five years. This workshop was organized to build on the progress made at previous meetings like the Nov. 2008 late-breaking symposium at the Annual Meeting of the Entomological Society of America in Reno, NV; the Nov. 2009 National TCD conference in St. Louis, MO hosted by the Missouri Dept. of Agriculture; and various workshops held in Kansas City, MO (April 2010), Denver, CO (June 2010), and West Lafayette, IN (March 2011). The interest in this topic is being driven by the economic value of the edible walnut industry from *Juglans regia* in California (approx. $0.5-0.75 billion/yr in annual income) and by the value of the *Juglans nigra* timber growing stock in the eastern U.S. (over $500 billion) (Newton and Fowler, 2009).

Seybold reviewed the history of invasive pathogens impacting hardwood trees in the U.S. and placed TCD as one of three major insect-vectored diseases of hardwoods (along with Dutch elm disease and oak wilt). The collection history of the beetle (1896 from New Mexico; 1907 from Arizona; 1959 from California; 1960 from Mexico) and the history of walnut mortality now attributed to TCD were also reviewed. Mortality was first noted in the early 1990's in the Wasatch Mountains of Utah and in the Willamette Valley of Oregon. In 1997, *P. juglandis* was first associated with the dying trees in Utah Co. Utah. Subsequent WTB-associated mortality was noted in the Espanola Valley of NM (2001) and in Boulder Co. CO (2003). TCD was first detected in Yolo Co., CA in 2008 and in Knox Co., TN in 2010. The pathogen was named and described taxonomically in 2011 (Kolařik et al., 2011).

Seybold presented two research highlights on *P. juglandis*. A preliminary genetic analysis of the mitochondrial cytochrome oxidase I DNA sequences from over 40 U.S. populations reveals considerable genetic diversity in New Mexico, Arizona, and Colorado, and only limited genetic diversity in the Pacific Northwest, Idaho, Utah, and Tennessee. Approximately 15 California populations have been analyzed and they reveal an intermediate level of genetic diversity. There are about 40 mitochondrial DNA haplotypes cataloged so far. The data and the collection history suggest that *P. juglandis* originates from the Southwest. Cooperating scientists at the UC-Riverside Department of Entomology are continuing this research. The host colonization behavior and pheromone biology have been studied by Seybold's group by entomologists at the UC-Davis Department of Entomology. Male *P. juglandis* colonize cut walnut branches first; and a pheromone-based attractant has been used to monitor the flight behavior of the beetle in Davis since May 2010. There appear to be three peaks of flight (May, June/July, and August/September).

Distribution, Diversity, and Utilization of Walnut Genetic Resources, the Most Pressing Threats, and the Prospect for Genetic Improvement of Black Walnut Species Against Thousand Cankers Disease

Charles A. Leslie

Walnut Improvement Program, Dept. of Plant Sciences, UC-Davis, Davis, CA

Leslie briefly outlined the botanical characteristics, commercial uses, and geographical origins of the various walnut species, including the black walnuts of North and South America, the New

and Old World butternuts, and the Persian or "English" walnut, *J. regia*, grown commercially in California.

Production of Persian walnut in California has nearly doubled over the last decade to a current annual level of 500,000 in-shell tons with a farm gate value of approximately a billion dollars. More than half of the crop is now exported. Marketing has publicized the high omega-3 fatty acid content of the kernels and emphasized the use of walnuts in a healthy diet.

The rootstocks of choice for Persian walnut orchards in California are the northern California black walnut, *J. hindsii*, or its hybrid with Persian walnut, *J. hindsii x J. regia*, known as 'Paradox'. These are preferred for their superior vigor, adaptation to California soils, and pathogen resistance. *Juglans hindsii* is native to limited riparian areas of northern California, but the species has been widely planted in rural and urban landscapes; is an important component of riparian habitats; and is utilized extensively by commercial nurseries. This resource, and potentially California walnut production in general, is now threatened by TCD. Identification and incorporation of genetic resistance offers one solution. Several other examples of pathogen resistance found in walnut species and utilization of these in current breeding efforts were discussed, including *J. ailantifolia* hybrids with resistance to butternut canker, crown gall and *Phytophthora* resistance identified in *J. microcarpa*, and lesion nematode resistance found in *J. cathayensis*.

Thousand cankers disease is now well established on the site of the USDA-ARS National Clonal Germplasm Repository *Juglans* germplasm collection at Davis and Winters, CA. On the one hand, this potentially threatens the continued existence of a very valuable genetic resource, but it also presents a unique opportunity for researchers to study TCD within a diverse set of mature walnut trees.

Epidemiology of Thousand Cankers Disease: The Fungal Aspect, Biology of the Pathogen, Outreach, and Implications for Forest Management

Ned A. Tisserat

Professor of Plant Pathology, Dept. of Bioagricultural Sciences and Pest Management, Colorado State University, Fort Collins, CO

Tisserat presented an overview of epidemiology of TCD. The fungal pathogen, *Geosmithia morbida*, is the first species in the Bionectriaciae reported as a phytopathogen (Kolařik et al., 2011). It has only been recovered from *P. juglandis* or from cankers in diseased walnut trees. The fungus causes the formation of cankers following introduction into the phloem by the beetle. These cankers subsequently coalesce to kill large areas of the bark, and ultimately results in tree mortality. Thousand cankers disease is now widespread on *J. nigra* in the western United States (Tisserat et al., 2011). An analysis of the rDNA ITS sequences from over 150 isolates indicated a complex population structure with at least nine haplotypes. Surprisingly, the haplotype diversity of isolates of *G. morbida* from *J. nigra* in Colorado was greater than that found on isolates collected from *J. major*, the putative native host of the beetle and fungus, in Arizona and New Mexico. In addition, the most frequent haplotype in Colorado, California, and Oregon was absent in Arizona. This may reflect the need for even wider collecting of isolates. Canker development is influenced by both temperature and the physiological status of the tree, with almost no canker formation occurring during tree dormancy. *Geosmithia morbida* often coats the *P. juglandis* galleries and pupae, but apparently does not harm the insect. Preliminary evidence suggests that *P. juglandis* larvae are attracted to agar plugs colonized by *G. morbida*.

Developing the *National Response Framework for Thousand Cankers Disease (TCD) on Walnut*: Administrative and Technical Challenges

Bruce Moltzan

Chair, Thousand Cankers National Technical Working Group, USDA Forest Service, Forest Health Protection, Washington, DC

Thousand Cankers Disease (TCD) was named to describe the complex between walnut twig beetle activity in the phloem and subsequent formation of numerous cankers caused by this fungus. Thousand cankers disease is now known to occur in Arizona, California, Colorado, Idaho, Oregon, New Mexico, Tennessee, Utah, and Washington in the U.S. Both the beetle and the fungus are considered native to the Southwest, where they are found on Arizona walnut, *J. major*. The discovery of TCD in Tennessee (2010) is thought to be significant, since it represents the first find occurring within the native range of *J. nigra*. The disease poses a threat to native and introduced walnut species across the U.S. since these are highly valued for timber, harvested for their nuts, used as ornamentals, and considered integral components within natural forest ecosystems. Other species in the Juglandaceae have shown varying susceptibility to TCD, and may also be at risk. A team of subject matter experts was convened by the United States Department of Agriculture Forest Service, in collaboration with its Animal Plant Health Inspection Service, and state departments of agriculture, state forestry agencies, as well as university researchers. *The National Response Framework for Thousand Cankers Disease on Walnut* was developed to link various levels of government, non-governmental groups, and private stakeholders to address the potential impact of TCD. Framework elements include: prevention, detection, management, outreach, and research and form the basis for broad partnerships, collaboration, and communication across various stakeholders. Information was presented on the current status of TCD in the U.S., as well as the administrative and technical challenges associated in developing collaborative frameworks and the expected benefits provided through this process.

Thousand Cankers Disease: Developing a Statewide Response in America's Black Walnut Breadbasket

Collin Wamsley

State Entomologist, Missouri Department of Agriculture, Plant Pest Control Bureau, Jefferson City, MO

Wamsley provided economic impact data for Missouri's black walnut, *Juglans nigra*, resource, citing a report by the Missouri Department of Conservation that predicts an $851 million loss over 20 years if TCD is introduced into Missouri. Missouri also has approximately 55 million black walnut trees in its forests and harvests, on average, 16.4 million pounds of black walnut nuts each year.

State responses to TCD consist of a three-pronged approach: Regulatory, outreach and survey. Currently 9 states have state exterior quarantines and 1 state (Tennessee) has a state interior quarantine. The relevant state departments of agriculture have worked together to develop uniform quarantines in the absence of a federal regulation, and are staying in close communication as more is learned about this pest complex that may affect current quarantines. Wamsley outlined the regulated articles, which are the pathogen and insect vector, *Juglans* wood including nursery stock, propagative wood, green lumber, logs, stumps, roots, branches, as well as

all non-coniferous firewood. Exemptions to the quarantine include nuts, nut meats, hulls, and processed lumber, which is defined at 100% bark free with squared edges and kiln dried. Also exempted are finished wood products such as gun stocks, musical instruments and furniture. Wamsley noted that enforcement is an issue but some states have been working with their state highway patrol to assist with the effort. Missouri conducted preliminary surveys in 2010 but is implementing a robust, statewide, multi-agency survey for 2011.

Panel Discussion

After the presentations, moderator Seybold opened the topic up for discussion with the audience. Questions included 1) Whether or not there was any evidence of hybridization of the fungus (no evidence of that so far); 2) Whether the fungus can penetrate the bark without the beetle (no evidence of that so far); 3) Whether debarked logs can be re-infected by the fungus or can carry the fungus (likely not); 4) The consistency of the directionality of the infection on the west side of trees (Tisserat and Seybold noted that this may vary a bit, but that the underside of the branches are often infested by the beetle before the upper side); and 5) whether the ultimate detection tool will be more like the gypsy moth trap or the EAB trap (Seybold answered that it will likely be more like a gypsy moth trap with a fairly powerful attractant).

Luncheon Discussion

Prior to the workshop, the panel members met over lunch to exchange ideas about the current and future status of the TCD problem in the U.S. Of primary concern was the potential for movement of raw walnut logs harboring *P. juglandis* from Tennessee to surrounding states. Also of concern was the continued movement of high quality raw walnut wood by brokers and woodworkers from the walnut industry and urban and rural sites in California and Oregon to other states in the U.S. Subsequently (Thurs., May 12), some of the panel members toured a walnut broker in the Portland area and learned that this company, at least, was now kiln drying its raw logs and walnut slabs prior to shipping them to consumers. Although the company was very aware of the TCD threat, it was still shipping untreated raw logs for veneer processing to Idaho. This practice in the past may have hastened the spread of *P. juglandis* among the western U.S. states. Raising awareness of the risks and providing treatment guidelines for this raw wood was thought to be paramount among the many issues that surround the TCD problem.

The panel also discussed applied research directions that the USDA Forest Service, Washington Office of Forest Health Protection is interested in seeing addressed in 2011. These included 1) a wounding study in the field (Iowa and Missouri) on *J. nigra* to understand what organisms colonize declining trees in the East (Northeastern Area FHP and Northern Research Station, J. Juzwik); 2) TCD management, including sanitation of infected materials by chipping (Region 2 FHP and Colorado State University, W. Cranshaw and N. Tisserat); 3) Host range, flight habits, and development of *P. juglandis* (Region 5 FHP and Pacific Southwest Research Station, S. Seybold); and 4) a forest survey of potentially infected areas in Tennessee and wood sanitation through heat treatment (Region 8 FHP). Other areas of emphasis include continued development of the baited trap for detection (PSW, Seybold); the further refinement of the understanding of the population genetics of *G. morbida* (Tisserat and K. Woeste, Purdue University) and *P. juglandis* (Seybold, R. Stouthamer, UC-Riverside Department of Entomology) through collection and analysis of populations (especially from Mexico and perhaps Texas and Puerto Rico if it occurs there);

the interaction of tree stress on the success of the TCD infection and branch mortality (Tisserat, Seybold, R.M. Bostock, UC-Davis Dept. Plant Pathology); and characterizing the spore load and frequency of spore phoresy of *G. morbida* by *P. juglandis* (Bostock and Seybold).

Some of the next steps that the panel discussed in the administrative aspects of the TCD problem included whether or not it was time to consider a synthesis of the scientific issues (either through a written document or a meeting series modeled on the Sudden Oak Death or Emerald Ash Borer programs). The databasing of new county/state records of TCD (the IPHIS data system) and the need for preservation of *Juglans* germplasm were also considered key priorities. Among the detection and outreach issues raised by the panel were the increasing number of difficult cases of diagnosis that were anticipated to arise in the eastern U.S. The subcortical insect fauna in the eastern U.S. is more complex than that in the West and small larvae and damage signs associated with weevils, flatheaded borers, and native bark and ambrosia beetles may be easily confused with those of *P. juglandis*. As samples are collected from interceptions of infested walnut sawlogs in various eastern states, the NPDN labs, state agriculture department labs, and EDRR identifiers may be challenged with these diagnoses, especially in circumstances where adult beetles are absent. Appropriate training of personnel from these labs may be necessary in the near future, as well as transfer of molecular techniques for diagnosis. Another potentially important area of outreach will be training workshops on TCD for veneer buyers (primarily in the East); growers (primarily in California); and arborists (in California, Colorado, Pacific NW states, and Tennessee), all of whom may be involved in processing or moving beetle-infested logs. An important resource in California will be the farm advisor network (UC Cooperative Extension), who interact primarily with the walnut growers, and may also be able to raise awareness indirectly with the wood buyers through annual county-wide training sessions with the walnut grower communities. Sources of information for walnut wood buyers included Chuck Leslie (in California) and the document by Newton and Fowler (2009) (for the rest of the country). A final outreach item that was discussed was the value of "news blitzes" where local areas might be inundated with radio, print, and internet media announcements about TCD.

The panel also considered that the newly discovered infestation in the four counties in Tennessee may provide some research opportunities as a test site for trials of resistant *J. nigra* and for a survey for how the disease behaves in a contiguous forest setting. The group also discussed the need for a national risk assessment for TCD and plans were made to contact Marla Downing in the Fort Collins office of the Forest Health Technology Enterprise Team to suggest this.

Some of the challenges presented by the TCD problem that are encountered in many similar forest health scenarios are: 1) Communication barriers: there are 51 state plant regulatory officials, 50 different state foresters, and numerous federal agencies involved. 2) The agency cultures differ and there is variability in the level of interest and capacity to address the problem among the agencies and states. 3) Since TCD is a new problem of uncertain origin and identified at a time of budgetary austerity, the research gaps need to be prioritized and addressed. Because of this urgency, data collected on the problem need to be shared and stored in such a way that many parties can access it. Guidelines might need to be developed for accessing this data. 4) USDA Forest Service Forest Health Protection has a keen desire to have recommendations and guidelines for management of the disease for walnut growers (nuts and timber). All parties feel that outreach and education on the issue need to be supported by cutting-edge and accurate science.

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Session 16 – Concurrent Session

Secondary Effects of Exotic Invasions - Cascades of Ecological Change

Organizers: Joshua K Adkins and Lynne K. Rieske-Kinney

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Invasive insects and pathogens impact the environment along a spatial continuum from individual to ecosystem, both directly and indirectly. This can have dramatic impacts on the environment by altering trophic relationships and environmental conditions, and by displacing endemic species, ultimately disrupting ecosystem processes. Our speakers will discuss the cascading secondary effects of forest invaders from a range of ecosystems. A greater understanding of the secondary effects these invaders have on community structure and function is critical in order to develop conservation plans and restoration efforts for native biota.

Hemlock Woolly Adelgid Threatens the Integrity of Headwater Riparian Invertebrate Communities

Joshua K. Adkins and Lynne K. Rieske-Kinney

Department of Entomology, University of Kentucky, Lexington, KY

The hemlock woolly adelgid (*Adelges tsugae*: HWA) is an invasive insect native to Asia that feeds on all *Tsuga* species. Eastern hemlock (*T. canadensis* L.) is particularly susceptible to HWA and has suffered catastrophic mortality throughout much of its range. A critical component of eastern forests, eastern hemlock provides food and essential habitat for wildlife and regulates key ecosystem processes. In Kentucky eastern hemlock is found primarily in moist coves and headwater riparian zones, playing a key role in regulating air and stream temperatures, reducing stream turbidity, and stabilizing base flows. HWA is spreading rapidly throughout eastern Kentucky, a region where stream quality is already severely degraded from large-scale resource extraction such as logging and surface mining operations. Adelgid-induced hemlock mortality will likely exacerbate deterioration of stream quality in this region.

The objective of our study is to evaluate the effects of HWA on headwater stream quality. We are investigating differences between eastern hemlock dominated and deciduous dominated headwater streams to determine the extent to which HWA invasion will affect (1) stream and riparian macroinvertebrate community dynamics, (2) stream chemistry, and (3) other stream characteristics including temperature and conductivity. Preliminary results indicate that eastern hemlock significantly influences stream parameters including sulfate, pH, total carbon, and conductivity. Further, four benthic macroinvertebrate families across three functional feeding groups are more abundant in streams with corresponding eastern hemlock dominated riparian zones. These results suggest that changes in stream function will likely follow HWA associated mortality of eastern hemlock in headwater stream riparian zones.

Invasive Ant-Native Hemiptera Mutualisms Threatens the Arthropod Community and Ecosystem Functioning of a Previously Unsuitable Forest Habitat

John Brightwell

Center for Integrated Pest Management, North Carolina State University, Raleigh NC

The Argentine ant, *Linepithema humile* Mayr, is a notorious invasive species capable of invading urban, agricultural and natural ecosystems. It has the ability to alter ecosystems through displacement of resident ant species, reduction in arthropod diversity, and interference with seed dispersal. To date, it has been excluded from closed canopy forest ecosystems within its introduced range. The Argentine ant is dependent on mutualisms with honeydew-producing Hemiptera to survive in North Carolina, the northern limit of its American range. Limited honeydew resources appear to be the reason for its exclusion from closed canopy forest systems in North Carolina. The native terrapin scale, *Mesolecanium nigrofasciatum* (Pergande) provides the main summer source of honeydew in a large infestation of Argentine ants within a commercial park in North Carolina. This mutualism occurs on ornamental plantings of red maples, *Acer rubrum,* and has been shown to decrease host fitness. The Argentine ant also collects honeydew on the native loblolly pine, *Pinus taeda.* This tree appears to be the only source of winter honeydew within the park. Both the red maple and loblolly pine are the dominant species of mixed forest remnants commonly found throughout the southeast United States of America. These mixed

forest systems abut the infested commercial park and, indeed, Argentine ants can be found foraging on some loblolly pines located on the edge of these forest remnants. The mutualisms on red maple and loblolly pine offer a potential pathway for permanent establishment within a closed canopy forest system, a habitat previously considered unsuitable for the Argentine ant. At least one of the described Argentine ant mutualisms decreases host fitness and similar effects could occur to other host trees. Along with known consequences to resident arthropod diversity and ecosystem functions, the potential establishment by the Argentine ant may result in severe degradation of these mixed forest remnants.

The impacts of Cryptic Invaders: Birch Leafmining Sawflies in North America

Christian MacQuarrie

Natural Resources Canada, Canadian Forest Service , Great Lakes Forestry Centre, Sault Ste. Marie, ON

{No abstract submitted.}

Oak Mortality and Two Borers: a Co-Evolved Relationship in the Eastern U.S. and an Introduced Relationship in the Western U.S.

Laurel J. Haavik[1], Fred M. Stephen[2], Tom W. Coleman[3], Mary Louise Flint[1], Robert C. Venette[4] and Steven J. Seybold[5]

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We explored secondary ecosystem impacts in two different oak forest ecosystems with two different insect pests. In Arkansas upland oak hickory forests, we quantified tree mortality and potential regeneration as well as investigated the role of forest history on an outbreak of the native red oak borer (*Enaphalodes rufulus* (Haldeman)) that occurred ca. 1999 – 2005. We found that mortality levels continued to increase even after the red oak borer outbreak was over and oak regeneration potential appeared to be minimal. Although successional processes were likely altered by human influence on forest history the system would likely be resilient in terms of forest cover, possibly by more shade tolerant species. In southern California oak woodlands a recently introduced invasive species, the goldspotted oak borer (*Agrilus auroguttatus* Schaeffer), has been associated with increased oak mortality since 2008. We found that oaks that had previously sustained greater goldspotted oak borer numbers currently contained greater numbers of other wood borer larvae. While goldspotted oak borer infestation may positively influence native wood borer populations, oak mortality leaves little habitat, food and cover for the native wildlife in southern California. Effects of this insect will likely be more ecologically catastrophic than the successional alterations related to the red oak borer outbreak in Arkansas.

Invasive Pathogen in Whitebark Pine Ecosystems: Trophic Cascades and Functional Losses

Diana F. Tomback[1] and Shawn T. McKinney[2]

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White pine blister rust, which is caused by the exotic fungal pathogen *Cronartium ribicola*, infects five-needle white pines (genus *Pinus*, subgenus *Strobus*, Family Pinaceae). Introduced to western North America in the early 20th centur y, this invasive disease is resulting in ecological disruption—bottom-up effects--and functional losses of whitebark pine (*Pinus albicaulis*), which has little natural resistance. Considered a keystone and foundation species, whitebark pine enhances community biodiversity, and fosters community development after disturbance and at treeline. It depends on the bird, Clark's nutcracker (*Nucifraga columbiana*), for seed dispersal. Nutcrackers are the primary source of regeneration for the pine, and determine pine distribution. The widespread damage and mortality from blister rust, coupled with recent mortality from current outbreaks of mountain pine beetle (*Dendroctonus ponderosae*), are reducing cone availability to nutcrackers. Our studies indicate that in areas of high damage and mortality, many seeds are lost to pre-dispersal predation by nutcrackers and red squirrels (*Tamiasciurus hudsonicus*). The lower the cone production within a stand, the lower the probability of seed dispersal by nutcrackers. These conditions are leading to a loss of whitebark pine communities, whitebark pine regeneration, and forest diversity, as well as the ecological functions and services they provide.

Session 17 – Concurrent Session

Bark Beetles and Stand Structure Following Thinning in Coniferous Forests

Organizers: Christopher J. Fettig[1], A. Steven Munson[2], and John T. Nowak[3]

[1]USDA Forest Service, Pacific Southwest Research Station, Invasives and Threats, Davis, CA; [2]USDA Forest Service, Intermountain Region, Forest Health Protection, Ogden, UT; [3]USDA Forest Service, Southern Region, Forest Health Protection, Southern Pine Beetle Prevention Program, Asheville, NC

Presentations:

Why All Thinnings are Not Created Equal – Factors Influencing the Susceptibility of Forest Stands to Bark Beetle Infestations

Christopher J. Fettig[1], A. Steven Munson[2], and John T. Nowak[3]

[1]USDA Forest Service, Pacific Southwest Research Station, Davis, CA; [2]USDA Forest Service, Intermountain Region, Forest Health Protection, Ogden, UT; [3]USDA Forest Service, Southern Region, Forest Health Protection, Asheville, NC

A Canadian Silviculturist's Perspective on the Effectiveness of "Thinning" to Reduce Susceptibility to Mountain Pine Beetle (*Dendroctonus ponderosae* Hopk.)

Roger J. Whitehead[1] and Greg D. Smith[2]

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Effect of Stand Density on In-Stand Gas Concentrations: Experience Using an Atmospheric Tracer in Forest Canopies

Harold W. Thistle[1], Tara Strand[2], and Brian L. Strom[3]

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Modeling Southern Pine Beetle Activity under Different Thinning Regimes and Planting Densities

James R. Meeker[1], John W. Bishir[2], and Brian L. Strom[3]

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Session Summary

Thinning has long been advocated as a preventive measure to alleviate or reduce the amount of bark beetle-caused tree mortality. Bark beetle prevention efforts have focused on forest thinning as a mechanism for reducing tree stress. For example, the SPB Prevention Program has treated 1 million acres in 13 states and 12 national forests. All of the program treatments are aimed at reducing the potential impact of southern pine beetle by increasing tree vigor and changing the stand structure. The question must be asked if all types of stand thinning and other preventative treatments are equally effective at reducing susceptibility. Also, what is the most important mechanism of stand and tree resistance resulting from thinning: increased tree vigor or change in stand structure? While early accounts regarding thinning effectiveness were attributed to increases in host tree vigor, further analyses yields several important variables at play. For example, thinning affects the residual size, distribution and abundance of preferred hosts and the physical environment within forest stands. For example, Strand discussed a study that showed stands thinned to a basal area of 70 sq ft had more wind flow within the stand and that a pheromone surrogate tracer gas was more likely to escape the tree canopy in thinned stands versus a stand with a basal of greater than 140 sq ft. Also prescribed fire used in conjunction with thinning may improve stand structure by opening up the stand which changes the pheromone plume dynamics in the forest. Increased temperatures and windspeeds are common following thinning and may cause turbulence that disrupts pheromone plumes used for recruiting conspecifics during initial phases of host tree colonization. Changes in microclimate also affect beetle fecundity and fitness, phenology and voltanism as well as that of predators, parasites and competitors. This symposium addressed these and related factors, and highlighted their importance in preventing bark beetle infestations by thinning at the stand level. Thinning by spacing may be more effective at reducing forest susceptibility to bark beetles than row thinning which is a common practice in the southern U.S. Smith discussed the current catastrophic mountain pine beetle outbreak in British Columbia and their attempts to save stands through thinning. Even under immense bark beetle pressure, stands that had been thinned by spacing and had an open understory showed resistance to mountain pine beetle. Additionally it is difficult to create large field studies to test these hypotheses, particularly when bark beetle populations are low, modeling studies may help in this regard. Meeker discussed a model (SPBLOBTHIN) that allows us to visualize and analyze various stand planting densities and thinning regimes in relationship to loblolly pine growth and SPB infestation dynamics.

Session 18 – Concurrent Session

What Kills Bark Beetle-Attacked Trees and Why It Matters

Organizer: Richard Hofstetter

School of Forestry, Northern Arizona University, Flagstaff, AZ

Introduction: How do Bark Beetle-Attacked Trees Die?

Richard Hofstetter

School of Forestry, Northern Arizona University, Flagstaff, AZ

Microbial symbionts are critical for the survival, reproduction, or development of many bark beetle species and have traditionally been believed to help overcome tree defenses. However, some have recently argued that fungal associates only benefit beetles by mediating competitive interactions with other fungi and support survival and efficient resource capture in trees. The question of how trees die when attacked by bark beetles is still debated.

Competing theories on the Relative Importance of Microbes and Bark Beetles

Paul Krokene

Department of Ecology and Natural Resource Management, Norwegian University of Life Sciences, Norway

Bark beetles are important killers of conifers worldwide and the beetle's microbial symbionts have traditionally been considered important partners in overcoming tree defenses. The major challenge for tree-killing bark beetles is the requirement to kill large and well-defended conifer hosts in order to reproduce successfully. Several lines of evidence support the classical theory that the bark beetle-microbe complex acts synergistically to kill trees, but there are also important inconsistencies in the theory and unexplained differences between biological systems. Despite recent challenges to the classical theory there are still no alternative hypotheses that adequately explain how bark beetle-attacked trees are killed.

How Can We Best Test Whether Fungi Assist Bark beetles in Contending with Tree Defenses? Ideas Welcome!

Ken Raffa

Department of Entomology, University of Wisconsin, Madison, WI

Not only are the roles of fungi in tree-killing by bark beetles inadequately understood, it's not even clear how best to test various models. Testing whether fungi assist beetles in contending with tree defenses, as opposed to more polar models of fungi killing trees directly or not contributing to this process, is especially difficult. The complexity of beetle-tree-fungal interactions makes direct experimentation difficult. This presentation provides no answers. Instead, I will offer some thoughts on how we can test putative relationships and conduct between-system comparisons, and solicit ideas on experiments to address this question as directly and practically as possible.

Management Implications: Does it Matter How Trees Die?

Kier Klepzig

Southern Research Station, USDA Forest Service, Asheville, NC

At least three theories have been offered for the mortality of bark beetle attacked trees: fungi kill trees, fungi exhaust host defenses, or fungi have no role. While these hypotheses may lead to academic debate and multidisciplinary research, the practical applications of these phenom-

ena are also worth considering. We ask whether knowledge of the ultimate cause of tree death might impact the selection, application or efficacy of tree protection techniques. We look at the proposed mechanisms of action for fungicides, insecticides and defense elicitors. We review existing data on their efficacy and propose testable hypotheses arising from theory and practice.

Session 19 – Concurrent Session

Changing Climates and Trophic Interactions

Organizers: Patrick C. Tobin[1] and Brian H. Aukema[2]

[1]USDA Forest Service, Northern Research Station, Morgantown, WV; [2]Department of Entomology, University of Minnesota, Minneapolis, MN

Climate change can induce changes to species dynamics, and much attention has focused on the role of changing climates on altering the distribution, abundance, and seasonality of individual species. In contrast, attention to species interactions, and how changes in climatic regimes could alter these interactions, has been addressed only limitedly, perhaps in part due to the complexity in quantifying climate change even in an individual species. Despite this immense challenge, however, this critical void must be addressed, and in doing so represents an opportunity to bridge current studies on the level of individuals to future studies that incorporate trophic interactions.

Effects of Climate Change on Species Interactions

Daniel A. Herms

The Ohio State University, Wooster, OH

{No abstract submitted.}

The Role of Plant Defenses Mediating Interactions between an Invasive Insect and a Community of Native Organisms in Boreal Forest

Nadir Erbilgin and Jessie Colgan

Department of Renewable Resources, University of Alberta, Edmonton, Canada

Coniferous trees deploy a combination of constitutive (pre-existing) and induced (post-invasion), structural and biochemical defences against invaders (Franceschi et al. 2005). Induced responses can also alter host suitability for other organisms sharing the same host, which may result in indirect, plant-mediated interactions between different species of attacking organisms. Current range and host expansion of the mountain pine beetle (*Dendroctonus ponderosae* Hopkins; MPB) from lodgepole pine-dominated forests to the jack pine-dominated boreal forests provides a unique opportunity to investigate whether the colonization of jack pine (*Pinus banksiana* Lamb.) by MPB will be affected by induced responses of jack pine to a native herbaceous insect species: the jack pine budworm (*Choristoneura pinus pinus* Freeman; JPBW). We simulated MPB attacks with one of its fungal associates, *Grosmannia clavigera* and tested induction of either herbivory by JPBW or inoculation with the fungus followed by a challenge treatment with the other organism on jack pine seedlings and measured and compared monoterpene respons-

es in needles (Colgan & Erbilgin, In press). There was clear evidence of an increase in jack pine resistance to *G. clavigera* with prior herbivory, indicated by smaller lesions in response to fungal inoculations. In contrast, although needle monoterpenes greatly increased after *G. clavigera* inoculation and continued to increase during the herbivory challenge, JPBW growth was not affected, but JPBW increased feeding rate to possibly compensate for altered host quality. Jack pine responses varied greatly and depended on whether seedlings were treated with single or multiple organisms, and their order of damage.

Franceschi, V.R., Krokene, P., Christiansen, E. & Krekling, T. (2005) Anatomical and chemical defences of conifer bark against bark beetles and other pests. *New Phytologist*, 167, 353–376.

Colgan LJ, N Erbilgin. Tree-Mediated Interactions between the jack pine budworm and a mountain pine beetle fungal associate. *Ecological Entomology*. In press.

Climatic Variation and Species Interactions in a Northern Hardwood Forest

Nina Lany and Matt Ayres

Dartmouth College, Hanover, NH

{No abstract submitted.}

Multitrophic and Community Structure Responses to Ciimatic Variation: Past and Potential Ecological Changes in Forests

R. Talbot Trotter III[1], Alexander Evans[2], Gina Wimp[3], and Thomas G. Whitham[4]

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{No abstract submitted.}

Session 20 – Concurrent Session

Informing Current Research on Wood and Bark-Boring Beetles with Lessons from the Past

Organizers: Chris J. K. MacQuarrie and Krista Ryall

Natural Resources Canada, Canadian Forest Service, Great Lakes Forestry Centre, Sault Ste. Marie, ON

Forest entomology in the North is in a phase of renewal and change. Recent outbreaks of native species and invasions by non-native wood- and bark-boring beetles (WB3) have prompted a shift away from our focus on defoliators. However, we have a long history of research on WB3; our question is: are we using that knowledge to inform our work today? Or are we merely reinventing the wheel? To answer the question, we will use examples from Canada and Alaska to examine the historical context of WB3 research and to gauge if past lessons are informing current research.

Bark Beetle Disturbance in Quebec and Atlantic Canada: Can the East Compete With the West?

Deepa Pureswaran[1] and Jon Sweeney[2]

[1]Canadian Forest Service, Laurentian Forestry Centre, Quebec City, QC; [2]Canadian Forest Service, Atlantic Forestry Centre, Fredericton, NB

The spruce beetle, *Dendroctonus rufipennis,* the eastern larch beetle, *D. simplex* and the recently-established exotic brown spruce longhorn beetle, *Tetropium fuscum* are among the prominent coleoptera in Eastern Canada. *D. rufipennis* and *T. fuscum* co-attack mature spruce trees. When the establishment of *T. fuscum* in Canada was confirmed, research activity focussed on developing pheromone lures for survey and detection. Investigations on biological control such as auto-dissemination of pathogens like *Beauvaria* are also underway and injection of systemic insecticides is being tested to protect high value trees. We are asking the same questions and implementing the same management strategies time after time. Lessons learned from pioneering research on western bark beetles in the 1960's and '70s continue to inspire us in managing current outbreaks.

Historical Perspective on Native and Exotic Bark and Wood Boring Beetles in Ontario

Sandy Smith[1] and Krista Ryall[2]

[1]Faculty of Forestry, University of Toronto, Toronto, ON; [2] Natural Resources Canada, Canadian Forest Service, Sault Ste. Marie, ON

{No abstract submitted.}

Ecology and Management of the Mountain Pine Beetle and Spruce Beetle: Some Highlights of Past Research in British Columbia

Bill Riel and Les Safranyik

Natural Resources Canada, Canadian Forest Service, Pacific Research Centre, Victoria, BC

Highlights of research on two important bark beetle species in British Columbia, the mountain pine beetle (*Dendroctonus ponderosae* Hopk.) and Spruce Beetle (*Dendroctonus rufipennis* (Kirby)) are explored. Important discoveries from several avenues of research are examined and possible implications for present day research into bark beetles are suggested. Research areas highlighted include host-insect interactions, role of climate and weather, insect dispersal, risk and susceptibility assessment and population and impact modelling.

A Semiochemical View of the Northern Spruce Engraver, *Ips perturbatus* (Coleoptera: Scolytidae), in Alaska: from Attraction, to Interruption, to Tree Protection

Andrew Graves

USDA Forest Service, Southwestern Region, Forest Health Protection Albuquerque, NM

{No abstract submitted.}

Historical View of Research in Forest Entomology: Turning Limitations and Future Directions into a Potential Research Idea

Nadir Erbilgin

Department of Renewable Resources, University of Alberta, Edmonton, AB

Over 1000 papers published on the mountain pine beetle (MPB) for the past century. Historically, few of those focused on the possible range and host expansion of MPB. The earliest paper by Furniss & Schenk (1969) investigated natural MPB infestation in 7 host tree species, including

Pinus banksiana, *P. nigra, P. resinosa, P. rigia, P. strobus, P. sylvestris,* and *Picea abies* in plantations in Idaho and found that MPB successfully colonized and produced brood on jack pine. Following paper by Amman (1982) demonstrated that among different host tree species, *P. ponderosa, P. monticola, P. albicaulis,* and *P. contorta*, MPB was very successful colonizing whitebark pine. Cerezke (1995) assessed whether jack pine was as a potential new breeding host and compared MPB colonization on lodgepole, limber, and jack pine logs. Logs of three hosts were placed together in multiple field experiments. He found that MPB's attack characteristics, survival, and progeny on jack pine were similar to those on lodgepole pine. More recently, Logan & Powell (2001) evaluated a stage-specific phenology model of MPB to evaluate the suitability of particular weather and climate for producing an adaptive seasonality. They found a greater than 7° shift North in latitude which corresponds to about 2.5°C increase. Based on these results, they predicted that a range expansion of 7° N would not only allow MPB to occupy previously unoccupied lodgepole pine habitat (range expansion) but also would allow invasion of previously unattacked jack pine (host expansion). As predicted by these historical studies, the beetle has expended its range to jack pine forest in Alberta in 2010. Many investigators in both Alberta and British Columbia have involved in various aspects of MPB. My program focuses on invasion of jack pine forest by MPB as a model study system and investigates interspecific interactions between MPB and native organisms occurring in jack pine, such as jack pine budworm or dwarf mistletoe. I believe understanding of host defenses is likely the cornerstone of this relationship. My goal is to evaluate how indirect interactions of MPB with native organisms will mediate the outcome of MPB-jack pine interactions and to predict the invasion success of MPB in jack pine boreal forest and to develop pest management strategies.

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Cerezke, HF. (1995). Egg gallery, brood production, and adult characteristics of mountain pine beetle, *Dendroctonus ponderosae* Hopkins (Coleoptera: Scolytidae, in three pine hosts. Can Ent, 127, 955-965.

Furniss, M.M. & Schenk, J.A. (1969). Sustained natural infestation by MPB in 7 new *Pinus* and *Picea* hosts. J Econ Ent, 62, 518-519

Logan, J.A. & Powell, J.A. (2001). Ghost forests, global warming, and the mountain pine beetle. Am Ent, 47,160-73.

Session 21 – Concurrent Session

Sirex in North America: a Conversation on Current Research

Organizers: Frederick M. Stephen[1] and Ann E. Hajek[2]

[1]Department of Entomology, University of Arkansas, Fayetteville, AR; [2]Department of Entomology, Cornell University, Ithaca, NY

The 2004 discovery of *Sirex noctilio* in New York has prompted a quick federal response in attempts to monitor, manage and limit the spread of this potentially serious pest species. Owing to a lack of basic knowledge about native North American *Sirex*, researchers from different parts of the country are beginning to study the biology of local species, including their parasitoids, symbiotic fungi and nematode parasitoids. Much of this work is in the early stages and publication of methods and results has not yet occurred. Sharing knowledge in relation to objectives, methods and results may prevent unnecessary duplication and stimulate new directions in research.

This workshop will provide a forum for unstructured discussion and conversation on current ongoing research on *S. noctilio*, native Siricidae, and their natural enemies and associates. The intent of the workshop is to enable researchers and graduate students to learn what their colleagues in different institutions are doing. The workshop is planned as a 1.5 hour discussion, without PowerPoint presentations, but rather focused on quick summaries of methods, results and plans for studies being conducted by researchers and students at different institutions.

Session 22 – Plenary Session

Bark Beetles and Fire Interactions in Western Coniferous Forests: Effects

(continued as Concurrent Session 23)

Organizers: Christopher J. Fettig[1] and Robert A. Progar[2]

[1]USDA Forest Service, Pacific Southwest Research Station, Davis, CA; [2]USDA Forest Service, Pacific Northwest Research Station, La Grande, OR

These sessions featured eight speakers that summarized our current understanding of the interactions among bark beetles, fires and fuels. Bark beetles may attack and kill trees that were injured by fire (i.e., prescribed fire or low to moderate intensity wildfire), but that otherwise would have survived. A common concern is that fire-injured trees may serve as a source of beetles resulting in additional levels of tree mortality. Furthermore, bark beetles are well recognized as a major cause of tree mortality, and during outbreaks accumulations of hazardous fuels resulting from elevated levels of bark beetle-caused tree mortality is often a concern. However, recent and ongoing research indicates that while bark beetle-caused tree mortality alters fuel complexes and subsequent fire behavior, these changes vary considerably over time and among forest types.

Effects of Fuel Reduction Treatments on Bark Beetle Activity in the Western U.S.

Christopher J. Fettig

USDA Forest Service, Pacific Southwest Research Station, Davis, CA

Bark beetles are recognized as important tree mortality agents in western coniferous forests. Fuel reduction treatments may influence the amount and distribution of bark beetle-caused tree mortality at various spatial and temporal scales. For example, these treatments may affect the health and vigor of residual trees; the size, distribution and abundance of preferred hosts; and the physical environment within forest stands. Carelessly implemented treatments may result in physical damage to residual trees, soil compaction and increased rates of windthrow, increasing the likelihood of tree colonization by bark beetles, other subcortical insects and root pathogens. Furthermore, tree volatiles released during harvest operations and/or the application of prescribed fire are known to influence the physiology and behavior of bark beetles, and colonization rates of trees by bark beetles.

Levels of tree mortality following prescribed fire depend on numerous factors including, but not limited to, tree species, tree size, phenology, degree of fire-caused injuries, initial and post-fire levels of tree vigor, the post-fire environment, and the frequency and severity of other predisposing, inciting and contributing factors. Bark beetles may attack and kill trees that

were injured by prescribed fire, but that otherwise would have survived. These trees may then serve as a source of beetles and attractive semiochemicals (i.e., host volatiles and aggregation pheromones produced by many bark beetle species during host colonization) that attract other beetles into the vicinity resulting in additional levels of tree mortality. The propensity for many species of bark beetles to attack fire-injured trees has led to questions regarding how the amount and distribution of bark beetle-caused tree mortality may be affected by the application of prescribed fire and fire surrogate treatments. In recent years, a substantial body of work has been published.

Assessing Post-Fire Tree Survival in Oregon and Washington

R. A. Progar[1], D. Scott[2], C. Schmitt[2], L. Spiegel[2], B. Hostetler[2], B. Wilhite[2], A. Eglitis[2], K. Chadwick[2], C. Mehmel[2], D. Goheen[2], S. Acker[3], and L. Ganio[4]

[1]USDA Forest Service, PNW Research Station, La Grande; OR; [2]USDA Forest Service, Pacific Northwest Region, Forest Health Protection; [3]National Park Service, Olympic National Park, , Port Angeles, WA; [4]Oregon State University, College of Forestry, Corvallis, OR

The objectives of this project are to assess primary mortality of trees in Oregon and Washington caused by direct fire injury, and secondary mortality caused by insects attacking injured trees, and the causal impacts of factors such as time, spatial correlation, precipitation, elevation, and species. We are evaluating data from more than 13,000 trees from 25 wild and prescribed fires. Current efforts are directed toward evaluating existing models used to evaluate survival of pine and fir in the western United States. We have selected 27 models evaluating survival of western pine and fire and are currently using our data to evaluate the performance of these models. We will develop a model for use in Oregon and Washington and evaluate the impact of bark beetles on the mortality of fire injured trees in Oregon and Washington. We are currently in the analyzing the data for this project.

Predicting Mortality for Five California Conifers Following Wildfire

Sharon M. Hood[1], Sheri L. Smith[2], and Daniel R. Cluck[2]

[1]USDA Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory, Missoula, MT; [2]USDA Forest Service, Forest Health Protection, Region 5, Susanville, CA

Fire injury was characterized and survival monitored for 5,677 trees > 25 cm DBH from five wildfires in California that occurred between 2000 and 2004. Logistic regression models for predicting the probability of mortality 5-years after fire were developed for incense cedar (*Calocedrus decurrens* (Torr.) Florin), white fir (*Abies concolor* (Gord. & Glend.) Lindl. ex Hildebr.), sugar pine (*Pinus lambertiana* Douglas), Jeffrey pine (*P. jeffreyi* Balf.), and ponderosa pine (*P. ponderosa* C. Lawson). Differences in crown injury variables were also compared for Jeffrey and ponderosa pine. Most mortality (70-88% depending on species) occurred within 2 years post-wildfire and had stabilized by year 3. Crown length and crown volume injury variables predicted tree mortality equally well; however, the variables were not interchangeable. Crown injury and cambium kill rating was significant in predicting mortality in all models. DBH was only a significant predictor of mortality for white fir and the combined ponderosa and Jeffrey pine models developed from the McNally Fire; these models all predicted increasing mortality with increasing tree size.

Red turpentine beetle (*Dendroctonus valens*) was a significant predictor variable for sugar pine, ponderosa pine, and Jeffrey pine; ambrosia beetle (*Trypodendron* and *Gnathotrichus* spp.) was a significant predictor variable for white fir. The mortality models and post-fire tree survival characteristics provide improved prediction of 5-year post-wildfire tree mortality for several California conifers. The models confirm the overall importance of crown injury in predicting post-fire mortality compared to other injury variables for all species. Additional variables such as cambium kill, bark beetles, and tree size improved model accuracies, but likely not enough to justify the added expense of data collection.

Hood, S. M.; Smith, S.; Cluck, D. 2010. Predicting tree mortality for five California conifers following wildfire. Forest Ecology and Management. 260: 750-762.

A Holocene Record of Spruce Beetles, Wildfire and Vegetation from a High Elevation Basin from the Wasatch Plateau, Utah, USA

Jesse L. Morris[1], Andrea Brunelle[1], A. Steven Munson[2], and Mitchell J. Power[1,3]

[1]Department of Geography, University of Utah, Salt Lake City, UT; [2]USDA Forest Service, Forest Health Protection, Ogden, UT; [3]Utah Museum of Natural History, University of Utah, Salt Lake City, UT

Wildfire and bark beetles (Dendroctonus spp.) are important disturbance agents in conifer-dominated landscapes in western North America. Our research investigates how historic bark beetle disturbances are recorded in pollen and macrofossils assemblages extracted from lake sediment cores. An analysis of sediments corresponding to the historical period reveals that spruce beetle (D. rufipennis) outbreaks have pronounced impacts on pollen accumulation, however preservation of useful insect remains are not common. Results from the historical pollen records were applied to two lake sediment records spanning the Holocene (last 11,500 years) to assess how past climate change influenced forest composition and disturbance. The resulting research provides new insights into the environmental history and disturbance regime variability of subalpine spruce/fir forests in central and southern Utah. As these ecosystems evolved from the cool temperatures of the late Pleistocene and early Holocene to the comparatively warm middle Holocene, the forest structure transitioned from spruce parkland to closed-canopy spruce/fir forest. Coincident with greater stand density and fuel/host continuity, wildfire and spruce beetle disturbance events became more frequent. Our records suggest that epidemic spruce beetle events recur at multicentennial intervals and that the mean fire return interval for significant fire episodes is similarly long, ranging between 300-500 years.

Session 23 – Concurrent Session

Bark Beetles and Fire Interactions in Western Coniferous Forests: Fuels and Fire Risks

(continuation of Plenary Session 22)

Organizers: Christopher J. Fettig[1] and Robert A. Progar[2]

[1]USDA Forest Service, Pacific Southwest Research Station, Davis, CA; [2]USDA Forest Service, Pacific Northwest Research Station, La Grande, OR

Impact of a Pinyon Ips Outbreak on Fuels and Wildfire Potential in Piñon-Juniper Woodlands of Arizona

Carolyn Hull Sieg[1], Rodman R. Linn[2], Chad M. Hoffman[3], Judy Winterkamp[2], and Joel D. McMillin[4]

[1]USDA Forest Service, Rocky Mountain Research Station, Flagstaff, AZ; [2]Los Alamos National Laboratory, Earth and Environmental Sciences Division, Los Alamos, NM; [3]Wildland Fire Program, College of Natural Resources, University of Idaho, Moscow, ID; [4]USDA Forest Service, Southwestern Region, Forest Health Protection, Flagstaff, AZ

The purpose of this study was to use a physics-based model, HIGRAD/FIRETEC, to explore fire propagation relative to time-since-outbreak in pinyon-juniper woodlands following drought-induced bark beetle attacks and subsequent tree mortality. Pinyon-juniper woodlands are an extensive, but highly variable woodland type in western U.S. and Mexico. Trees often are clumped, with sparse patches of herbaceous and shrubby vegetation scattered between clumps. A drought-induced outbreak of pinyon ips between 2001 and 2003 resulted in widespread mortality of pinyon trees across vast areas of the Southwest. The presence of dead trees intermixed with live junipers raised concerns about increased fire hazard, especially immediately after the trees died and dead needles remained in the trees. Based on stand and fuels data during and after the outbreak, we used FIRETEC to explore the coupled fire/vegetation/atmospheric interactions under low and high wind speeds in an attempt to identify thresholds associated with extreme fire behavior in these highly heterogeneous woodlands. We were also interested in how these interactions changed in woodlands without tree mortality ("live"), in the first year when dried needles clung to the dead trees ("dead"), and when the needles dropped to the ground ("dropped"). Our simulations suggest that fire propagation increases three-fold at low wind speeds (4 m sec^{-1} at 10-m height) when dead needles are on the trees compared to live woodlands and simulations with dead needles on the ground. At high wind speeds (7 m sec^{-1}), fire propagation in woodlands with dead needles on the trees increased only slightly above that in live woodlands or those with needles on the ground. This study suggests that the fire/vegetation/atmospheric interactions are complex across high spatial and temporal heterogeneity following a drought-induced bark beetle mortality event.

Temporal Dynamics of Ground, Surface, Ladder, and Crown Fuels and their Potential Effects on Fire Behavior, Following *Dendroctonus ponderosae* Epidemics in the *Pinus contorta* Zone of South-Central Oregon

David Shaw[1], Travis Woolley[1], Stephen A. Fitzgerald[2], and Laurie L. Kurth[3]

[1]College of Forestry, Oregon State University, Corvallis, OR; [2]Deschutes County Extension Service, Oregon State University, Redmond, OR; [3]USDA Forest Service, Fire Modeling Institute, Missoula, MT

{No abstract submitted.}

Comparing Bark Beetle (*Dendroctonus spp.*) Effects on Fuels in Lodgepole Pine and Douglas-fir Forests of Greater Yellowstone

Daniel C. Donato[1], Martin Simard[2], Monica G. Turner[1], William H. Romme[3], Brian J. Harvey[1], and Jacob M. Griffin[1]

University of Wisconsin[1]; Laval University[2]; Colorado State University[3]

We evaluate how bark beetle outbreak-induced changes to fuel profiles change over post-outbreak time (0-35 years) in two major forest types of the Greater Yellowstone Ecosystem (GYE)—lodgepole pine (*Pinus contorta* var. *latifolia*) and Douglas-fir (*Pseudotsuga menziesii*). Surface fuel loads did not vary strongly over post-outbreak time in either forest type, especially in Douglas-fir. Canopy thinning and increased patchiness was an important effect of beetle mortality, potentially reducing active crown fire potential; how this interacts with altered needle flammability during the red-needle phase is unclear. In general, beetle effects on fuels were less important in Douglas-fir forests than in lodgepole pine, because changes associated with beetles were mostly within the wide range of variability inherent to Rocky Mountain Douglas-fir forest structure. However, in both forest types, the slow and partial nature of beetle disturbance was an important factor, generating asynchronous changes to canopy fuels and leaving significant live vegetation components within stands.

The Impact of Spruce Beetle on Fuels and Fire Behavior in Intermountain Engelmann Spruce Forests

Michael J. Jenkins[1] and C. Arik Jorgensen[2]

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{No abstract submitted.}

Session 24 – Concurrent Session

Single Tree Protection Tactics

Organizer: Donald Grosman

Texas Forest Service, Lufkin, TX

This session will provide a forum to review and discuss innovative developments in the field of single tree protection, particularly as they relate to novel products or approaches developed and evaluated in recent years.

The Latest Insecticides for Tree Protection

Daniel A. Herms

Department of Entomology, The Ohio State University, Wooster, OH

{No abstract submitted.}

Protecting Individual Conifers from Bark Beetle Attack Using Bole Sprays and Systemic Tree Injections

Christopher J. Fettig[1], Donald M. Grosman[2], A. Steven Munson[3], and C. Wayne Berisford[4]

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Tree losses associated with bark beetle attack in residential, recreational or administrative sites generally result in undesirable impacts such as reduced shade, screening, and aesthetics. Dead trees pose potential hazards to public safety, and property values may be significantly reduced by mortality of adjacent shade and ornamental trees. This presentation described, in brief, a decade of research on the development of insecticides for protecting individual trees from bark beetle attack in the U.S. Efforts have led to the availability of new insecticide formulations, new active ingredients, and the only effective systemic injection tool for protecting conifers from bark beetle attack in the western U.S. Other research determined the amount of environmental contamination occurring during insecticide bole sprays in the western U.S., which serve as the standard for prescribing no-spray buffers.

Control Options for Exotic Borers

Therese M. Poland[1], Deborah G. McCullough[2], Robert A. Haack[1], Leah S. Bauer[1], Toby R. Petrice[1], and Deborah L. Miller[1]

[1]USDA Forest Service, Northern Research Station, East Lansing, MI; [2]Departments of Entomology and Forestry, Michigan State University, East Lansing, MI

Systemic insecticides are useful in controlling wood-boring insects in landscape trees. The Asian longhorned beetle, *Anoplophora glabripennis* (Motschulsky) (Coleoptera: Cerambycidae), and the emerald ash borer, *Agrilus planipennis* Fairmaire (Coleoptera: Buprestidae), are two recently established invasive forest insect pests causing extensive tree mortality in areas of North America. The Asian longhorned beetle (ALB) is a pest native to China and Korea that was discovered in North America in 1996. Currently, the only reliable strategy available for eradication and control is to cut and chip all infested trees and injection of nearby host trees with systemic insecticides. We evaluated various doses of the systemic insecticides, azadirachtin (Ornazin™, 3.3%, Amvac Chemical), emamectin benzoate (Shot Wan™ Capsules, formerly Novartis now Syngenta), imidacloprid (Imicide™, 10% , Mauget) and thiacloprid (Thiacide™, 5% and 10%, Mauget) for control of ALB in naturally infested elms (*Ulmus)*, poplars (*Populus*), and willows (*Salix*) in China. We compared the number of dead ALB adults beneath treated and control trees and the density of live ALB life stages within the trees. Our results suggest injecting ALB-infested trees with imidacloprid can result in significant mortality of adults during maturation feeding on leaves and twigs and of all life stages feeding within infested trees. Although, injection with imidacloprid does not provide complete control of ALB, systemic insecticides may prove useful as part of an integrated eradication or management program. The emerald ash borer (EAB) was discovered in Detroit, Michigan in 2002. As of May 2011, it is present in 15 US states and 2 Canadian provinces and is estimated to have killed over 50 million ash trees. We evaluated several systemic insecticides in ash trees including: imidacloprid, (Imicide™; 10%, Mauget), emamectin benzoate, (TREE-äge™, 4%, ArborJet micro-injector); imidacloprid trunk spray (Macho 2F™, 21.4%) with and without Pentra-Bark™; and dinotefuron trunk spray (Safari™, 20%) with and without Pentra-Bark™. Emamectin benzoate provided nearly complete EAB control for two years post-treatment. Trees treated with imidacloprid or dinotefuran, particularly the trunk sprays that included Pentra-Bark, also had significantly lower EAB larval density than the control trees during the first year; however, the level of control was not nearly as high as that provided by the emamectin benzoate. Furthermore, these products provided virtually no control of EAB if they were not reapplied the second year.

Testing Systemic Insecticides for Management of Three Common Pests in Conifer Seed Orchards of the Intermountain West

Stephen Cook[1], Benjamin Sloniker[2] and Marc Rust[3]

[1]Department of Plant, Soil and Entomological Sciences, [2]Environmental Sciences program, [3]Inland Empire Tree Improvement Coop, all at University of Idaho, Moscow, ID

In western North America, conifer seed orchards are used to produce the crop of new trees to re-establish forests following disturbances such as wildfires and harvesting. The individual trees within these orchards are selected for various traits that include growth form and disease resistance. Orchards frequently contain multiple stems of individual clones or families of the selected trees and may contain multiple tree species and/or individual selections from multiple geographic or elevational ranges. The selection and propagation of these orchard trees frequently represents a considerable expense to the management unit.

There are various degrees of management within the various conifer seed orchards in the west ranging from very little input to intensive management that includes fertilization, irrigation and annual application of pesticides. Regardless of the level of management, conifer seed orchards represent an ideal resource for insects that rely upon conifer seed for their development. The three most important insect pests of conifer seed orchards in the inter-mountain west are fir coneworm (DA), western conifer seed bug (LO) and ponderosa pine cone beetle (CP).

We have initiated several experiments to test the use of systemic insecticides for the management of these three insect pests in seed orchards that produce Douglas-fir (PM), western white pine (PM) and ponderosa pine (PP). We have conducted several spring application trials using emamectin benzoate, imidicloprid and azadirachtin with mixed results. In our Douglas-fir trials testing the impact of bole-injected compounds, the best results were obtained using emamectin benzoate against fir coneworm followed by imidicloprid. The bole-injected azadirachtin did not decrease cone damage below the level of that measured in non-treated, control trees. Similar results were obtained in western white pine for management of fir coneworm but, no significant reduction in damge from ponderosa pine cone beetle was measured following application of any of the compounds. The lack of control is probably related to the early flight of this beetle during the spring. Direct assays to measure the impact of bole-injected emamectin benzoate and imidicloprid on western conifer seed bug are planned for this summer. In addition, we recently initiated a fall treatment trial using emamectin benzoate and imidicloprid in ponderosa pine (2010 application) and Douglas-fir (application of the compounds will occur in 2011) and results will be compared with spring applications of the compounds within the same orchards during the same growing season.

Session 25 – Concurrent Session

Potential for Breeding Host Resistance Against Invasive Forest Pests

Organizer: Fred P. Hain

Department of Forestry and Environmental Resources, NC State University, and the Alliance for Saving Threatened Forests

Historical Perspective on Breeding Trees Resistant to Forest Pests

Richard A. Sniezko

USDA Forest Service, Dorena Genetic Resource Center, Cottage Grove, OR

Insects and pathogens continue to cause major losses in managed forests and urban plantings as well as in natural forest ecosystems. Harnessing the natural genetic resistance of our tree species through resistance breeding provides a concrete and 'green' sustainable way of potentially mitigating this damage through restoration or continued use of valuable tree species in managed forests. Resistance breeding in trees began almost 100 years ago, but most programs are much more recent. In North America, the USDA Forest Service is a leader in such programs (e.g. *Phytophthora lateralis* resistance in *Chamaecyparis lawsoniana*, *Cronartium ribicola* resistance in a number of white pine species); tree improvement cooperatives are also major contributors for some species; as is The American Chestnut Foundation (TACF). Three major international workshops on resistance breeding were held from 1964 to 1980, and the fourth took place in summer 2011. Pending continued funding, the outlook for the future is bright for many of these programs.

Breeding Resistance to Chestnut Blight

Fred Hebard

The American Chestnut Foundation

The goal of TACF's breeding program is two-fold: to introduce into the American chestnut the genetic material responsible for the blight resistance of the Chinese tree, and at the same time, preserve in every other way the genetic heritage of the American species. Although the Chinese genes for resistance are only incompletely dominant, they nonetheless usually express themselves clearly when present in seedlings purposely inoculated with a virulent form of the blight fungus. And that is how each backcross generation is tested - by inoculation with blight. Only those seedlings that show the greatest resistance are used for further backcrossing to an American parent. But every backcross, although necessary to recover desirable American traits, also reintroduces the genes for blight susceptibility from the American parent. In order to remove those genes, the next steps at TACF are intercrosses. In the first intercross, the most blight-resistant 15/16ths American trees are crossed with other blight-resistant 15/16ths American trees. Again, only resistant seedlings are saved. At the first intercross, it may prove difficult to select inoculated seedlings which have only inherited genes for blight resistance from their Chinese ancestor and no genes for blight susceptibility from their American ancestors. Testing in subsequent generations or a test cross back to an American parent will confirm that first intercross trees contain only the Chinese genes for resistance. Most or all the progeny of parents containing only genes for blight resistance should show blight resistance, whereas some progeny of parents with genes for susceptibility should show susceptibility to blight. When crossed with each other, these highly blight-resistant parents will breed true for resistance, since they will have no American genes for susceptibility to blight. This second intercross will yield nuts for restoration.

The Role of Applied Forest Genetic Resource Conservation in the Development of Host Resistance Programs: The Importance of *Ex Situ* Strategies

Robert M. Jetton[1], William S. Dvorak[1], W. Andrew Whittier[1], and James "Rusty" Rhea[2]

[1]N.C. State University, Camcore, Department of Forestry & Environmental Resources, Raleigh, NC; [2]USDA Forest Service, Southern Region, Forest Health Protection, Asheville, NC

The concept of forest genetic resource conservation can be defined from a number of perspectives, but for the purposes of this symposium, it is best viewed as efforts to maintain, in perpetuity, the ability of tree species to evolve and thrive in changing environments and to adapt to new environmental stresses such as climate change and invasive pathogens and insects (FAO 2004). Although called "gene conservation", the genetic basis of the science is the conservation of alleles (different forms of the same gene on the chromosome) that occur at different frequencies (major, rare, and private or unique), and capturing those alleles in such a way that high genetic diversity and broad adaptability (adaptive variation) is maintained (Dvorak, *in press*). This can be accomplished through both *in situ* (in place) or *ex situ* (off site) conservation strategies (FAO 2004). *In situ* gene conservation is the most common strategy for forest tree species and ecosystems, and it involves maintaining natural populations in protected areas or nature reserves using either "hands off" or active management such as silvicultural prescriptions, pesticides, or biological control. *Ex situ* conservation is often used where tree species cannot be reliably conserved *in situ* and typically involves the collection of germplasm (seeds, stem cuttings, scion, etc.) for long-term preservation in cold storage or growing trees off site in plantations, seed orchards, or progeny tests. *Ex situ* is the strategy that is currently being employed by Camcore (an international tree breeding and conservation organization at N.C. State University) and the USDA Forest Service Forest Health Protection to conserve the genetic resources of both Eastern (*Tsuga canadensis*) and Carolina (*T. caroliniana*) from across their native ranges in the eastern United States where, despite continued efforts in biological and chemical controls, the invasive hemlock woolly adelgid (*Adelges tsugae*) continues to cause widespread mortality and localized population extinctions (Jetton et al. 2010). This effort is capturing genetically representative hemlock germplasm before it disappears so that the genetic resource will be available for restoration activities once effective adelgid management strategies are in place, and for adelgid resistance breeding programs such as that being carried out by the US National Arboretum (Olsen and Bentz 2010) or the program that has been proposed by the Alliance for Saving Threatened Forests (ASTF 2010).

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Olsen, R.T. and S.E. Bentz. 2010. Breeding novel hemlock hybrids with resistance to hemlock woolly adelgid. pp. 91-92 In: B. Onken and R. Reardon (Eds.), Proceedings of the Fifth Symposium on Hemlock Woolly Adelgid in the Eastern United States.

Developing Hemlocks Resistant to Hemlock Woolly Adelgid

K. L. F. Oten[1], L. N. Walker-Lane[2], R. M. Jetton[2], N. Kaur[2], B. Smith[2], J. Frampton[2], A. C. Cohen[2] and F. P. Hain[1]

[1]Department of Entomology, [2]Department of Forestry and Environmental Resources, all at NC State University, Raleigh, NC

The hemlock woolly adelgid (HWA), *Adelges tsugae*, is an exotic pest from Japan that threatens eastern and Carolina hemlock populations. Its range now includes 18 eastern states, and infested trees can die in as little as 4 years. Hemlock species vary in their susceptibility to the insect from very susceptible to resistant/tolerant. Work on foliar chemistry has shown that high N and K may increase palatability (Pontius et al. 2006), foliar terpenoids are related to alleged susceptibility with eastern and Carolina hemlock grouped together in the most susceptible category (Lagalante & Montgomery 2003), high levels of isobornyl acetate are found in eastern and Carolina hemlock (despite a distant phylogenetic relationships) (Lagalante et al. 2007), the presence of ***α***-hexacosanol in the epicuticular wax may stimulate HWA feeding (Kaur 2008), and there are high levels of ***α***-humulene in resistant/tolerant hemlock species (especially in the needle cushion during periods of feeding) (Lagalante et al. 2007). A study of the wood anatomy of infested branches showed abnormal wood in the xylem, which may cause water stress. This was confirmed by pre-dawn branch water potential measurements, carbon isotope ratios of the branches, and means of stomatal conductance (Rivera 2010). The Alliance for Saving Threatened Forests is an organization of scientists from various agencies and universities that are researching resistance/tolerance to HWA. Scanning electron microscopy is being used to determine feeding sites and HWA behavior, analyze and compare host surfaces, and to examine sheath material. Early screening studies have identified putatively resistant/tolerant eastern and Carolina hemlock. Common garden plantations are being established, and research into the mechanism of resistance/tolerance is being conducted. The National Arboretum in Washington, DC has developed a hybrid between Chinese and Carolina hemlock that is putatively resistant/tolerant to the adelgid. Ultimately a breeding and selection approach will be employed to develop resistant planting stock and accelerate natural selection in restoring fir and hemlock. A series of regional clonal seed orchards grafted from trees with verified resistance will be established to provide locally adapted resistant seed.

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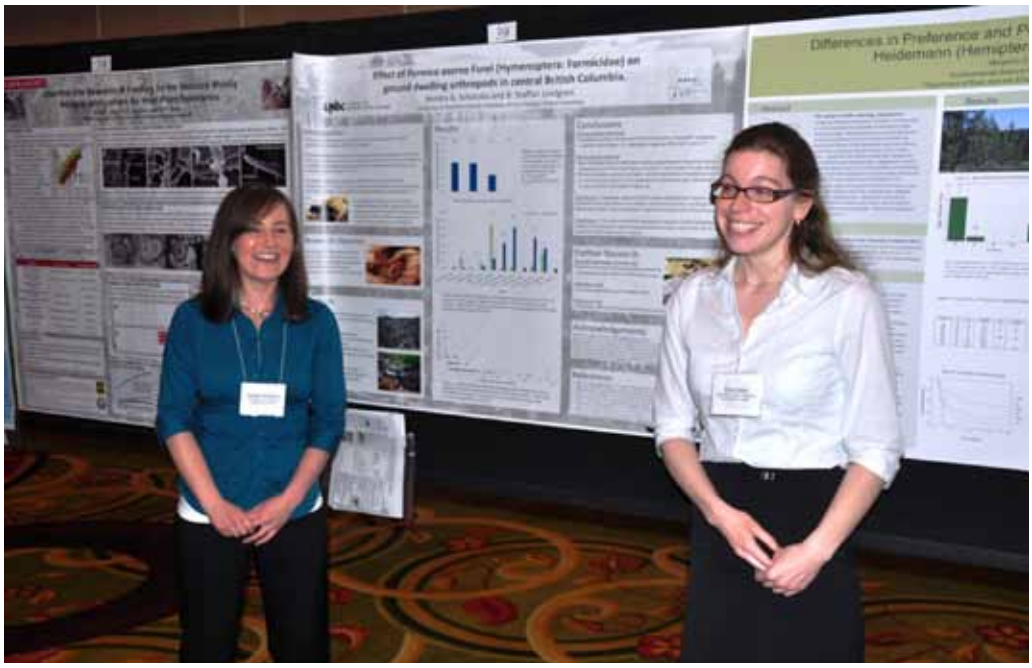
Potential for Breeding Resistance to the Emerald Ash Borer

Jennifer L. Koch[1], Kathleen Knight[1], David W. Carey[1], Therese Poland[2] Daniel A. Herms[3], and Mary E. Mason[3]

[1]USDA Forest Service, Northern Research Station, Delaware, OH; [2]USDA Forest Service, East Lansing, MI; [3]Department of Entomology, Ohio Agricultural Research and Development Center, The Ohio State University, Wooster, OH

Initially identified in the Detroit area in 2002, the invasive Emerald Ash Borer (EAB) has now been confirmed in 15 states. Native ash species are highly susceptible with mortality of over 99 % typically occurring within 3-7 years of infestation. We are currently employing two different breeding strategies for the development of EAB-resistant North American ash species. The first approach is to look for EAB-resistance in ash species that are native to the regions of origin of the insect and to utilize these species as parents in hybrid crosses with North American ash species. To initiate the identification of potential EAB-resistant exotic parents, we have been accessioning many different exotic ash species from across a wide taxonomic, geographic, and ecological range. The EAB phenotype for each accession will be determined through bioassays and/or natural infestation of field plantings. Many interspecific controlled cross-pollinations have been performed, and should the resulting F1 hybrids be EAB-resistant, they will likely have immediate value to the nursery industry. However, for restoration purposes, the long term goal is the introgression of the resistance genes from the exotic species into North American ash species through subsequent rounds of backcrossing. Such an approach would allow the retention of all of the traits of the North American species along with EAB-resistance, similar to the American Chestnut Foundation's hybrid breeding program. The second approach is to look for rare EAB resistance or tolerance in native North American ash species. We are identifying surviving North American ash in monitoring plots that have been established in natural stands where over 99 % of ash trees have been killed by EAB. These "lingering ash" that have a healthy crown, are in the dominant or co-dominant crown class (or open grown), and are large enough to have been exposed to EAB in the main infestation are selected for propagation and further study. Currently we have identified and grafted 33 lingering ash trees (both green and white ash). Initial bioassays have been conducted on a few of the genotypes. Analysis of adult EAB choice feeding bioassays has demonstrated that two of the lingering ash selections were less preferred than unselected seedling controls. These data were further supported by a natural EAB infestation in the nursery growing area at the Delaware, OH Forest Service laboratory in which some lingering ash selections remained uninfested while known susceptible selections in close proximity were infested. Controlled cross-pollinations between lingering ash have been performed and the resulting seedlings will be tested. Select lingering ash will also be used as parents in hybrid breeding.

POSTER SESSIONS



Student Poster Session – M.S. Students

M.S. Poster Competition -- Award Recipients

First Place: Kimberly Dean (ESF - SUNY)

Second Place: Amy Snyder (Virginia Tech)

Note: posters are listed in alphabetical order by students' last name

Mountain Pine Beetle: Allies and Enemies

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The mountain pine beetle (*Dendroctonus ponderosae* Hopkins) has caused significant economic and ecological impacts in western North American conifer forests, and continues to expand its range towards the jack pines of eastern North America. Beetle success in jack pine will depend largely upon colonization success of beetle microbial associates. Thus, the goal of our research is to determine the role of combinations of the associated bacteria and fungi on mountain pine beetle reproduction in jack pine, lodgepole pine, and hybrid jack-lodgepole pine. Our collaborators at the University of Wisconsin isolated four species of fungi and two species of bacteria that were commonly associated with the beetles, and two species of bacteria that were associated with colonized and un-colonized trees. Phloem samples from each tree species were used to

create phloem sandwiches inoculated with one of the fungal species. One male-female beetle combination treated with one of the bacteria species was introduced to each phloem sandwich. The number of eggs laid, maternal and larval gallery lengths, and larval survival were recorded. Preliminary results show that beetles laid a greater number of eggs in the presence of the fungus "Yellow" (to be identified) than in the presence of the fungus *Grosmannia clavigera*, regardless of tree species or bacteria present. D4-22 bacteria, an actinomycete associated with the beetle, encouraged higher beetle survival in lodgepole pine than in jack pine, and encouraged higher beetle survival in lodgepole pine than did AbA1, a pseudomonas bacteria associated with the beetle.

Native Siricidae and their Hymenopteran Parasitoids in Southeastern Forests: Who, what, when, where and how?

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The Eurasian woodwasp, *Sirex noctilio* Fabricius, is an introduced pest in North America. *Sirex noctilio* may be introduced to the southeastern U.S. region with potential economic and ecological impacts. In contrast with other *S. noctilio* invaded countries, native species of siricids and their hymenopteran parasitoids are common in North America. We studied the distribution and best trapping techniques for native siricids and their parasitoids in southeastern forests. In 2009, Georgia, Louisiana, and Virginia were sampled with intercept traps baited with *Sirex* lure alone, *Sirex* lure + ethanol, or unbaited. In Georgia funnel traps were also used with identical lures. A total of 23 trap logs were created from the three states. In 2010, intercept traps were operated with the same lures plus an ethanol alone lure and a lure with ethanol, *Sirex* lure, ipsenol, and ipsdienol. Panel traps were also operated in Louisiana that were either baited with the *Sirex* lure, a fresh pine log, or left unbaited. Preliminary results indicate that trap logs capture more siricids compared to using traps with lures, fresh pine captured more siricids compared to other lures and La captured significantly more parasitoids and siricids then Georgia or Virginia.

Impacts of Formosan Subterranean Termites on Forest Ecology

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The Formosan subterranean termite, *Coptotermes formosanus* Shiraki, is a highly destructive pest on wooden structures in the southern U.S. Formosan termites have been reported to infest living trees in urban areas along the Gulf Coast, causing significant structural damage. However, no studies have focused on Formosan subterranean termite prevalence, frequency of infestations, or species preference among living trees in forested settings. Formosan termites utilize the same resources as native *Reticulitermes* spp., and are known to be prolific feeders. This study will determine the potential of Formosan termites to displace native *Reticulitermes* spp. for foraging territory. Additionally, this research will investigate the frequency of Formosan termite infestations among living trees in forested stands, and determine which tree species are preferred. One-hundred 0.02 ha plots will be placed in forested areas within four Mississippi counties with

known Formosan termite presence. All living trees >15 cm in diameter and woody debris > 4.5 cm will be inspected for presence of termites, and termite species will be recorded along with tree species. This research will hold important implications for determining the impact Formosan subterranean termites have on native forest ecosystems.

A Comparison of Communities of Native and Exotic Subcortical Beetles around Nurseries and Warehouses in Southern Region

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Subcortical beetles including bark and wood-boring beetles (Coleoptera: Curculionidae, Buprestidae and Cerambycidae) are abundant, species-rich, and both ecologically and economically important in forested habitats. Native and exotic beetles are often moved around via plant materials shipped to nurseries and warehouses, allowing for the introduction of new species. Hence, these "ports-of-entry" need to be monitored regularly to allow rapid detection and early eradication of exotic beetles which can contribute to tree mortality. Beetles were trapped with Lindgren funnel traps in 2010 at seven sites in Georgia. Three and four study sites were, respectively located at warehouses and nurseries. Lures included: ethanol, α-pinene, and exotic *Ips* lure. A two-way analysis of variance was used to analyze the trap catches, and Shannon-Weiner and Simpson's indices were used to determine species diversity. Preliminary results indicate that 4,079 beetles consisting of 95 species and 63 genera were trapped. Semiochemical response varied between abundant species, most of which were exotic. Most of the beetles, especially exotic species, were trapped in nurseries rather than warehouses. Understanding species composition of nurseries and warehouses can help assess which areas are susceptible to invasion, and which pests are likely to invade elsewhere in the country.

Impacts of Cogongrass (*Imperata cylindrica* (L.) Beauv) on Populations of Root-Feeding Bark Beetles Associated with Pine Decline

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The non-native, invasive grass *Imperata cylindrica* (L.) Beauv. (cogongrass) is becoming an increasing threat to the diversity of native plant and wildlife species of the southeastern United States. Cogongrass infestations have also been found to affect pine ecosystems by altering fire regimes and limiting regeneration by forming extensive monocultures through rhizomatous growth. Another threat to southeastern pine forests is pine decline. The factors associated with pine decline include a complex of abiotic and biotic stressors that can cause economically significant premature mortality in mature pine forests. A suite of root-feeding bark beetles, which vector staining fungi associated with pine decline, are attracted to stressed pines. Cogongrass could potentially lead to pine decline by causing an additional stress to pines leading to higher infestations of root-feeding bark beetles. Twenty plots were established in a loblolly pine plantation located in southeastern Mississippi, ten of which were placed in areas with an extensive infestation of cogongrass and ten were placed in areas without cogongrass. Insect traps placed within each plot are checked on a bi-weekly basis to observe insect population trends. Current trends show that *Hylastes salebrosus* is the most common species observed and has shown

higher populations in cogongrass infested plots versus non-cogongrass plots. *Hylastes porculus*, *Dendroctonus terebrans*, and *Hylobius pales* have also shown similar trends, but populations are currently not significantly different between cogongrass and non-cogongrass plots. Diameter at breast height and crown ratio of trees located within each plot have been found to be significantly higher in cogongrass versus non-cogongrass plots but, many factors can influence these differences in growth.

Invasion by Exotic Earthworms Alters Biodiversity and Communities of Litter- and Soil-Dwelling Microarthropods.

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We used ecologically important oribatid mite (Archnidae: Acari) communities to study the responses of litter-and soil-dwelling microarthropod communities to exotic earthworm invasion in a northern temperate forest. Litter- and soil-dwelling mites were sampled in 2008-2009 from forest area 1) with no earthworms; 2) those with epigaeic and endogaeic species including Lumbricus rubellus Hoffmeister; and 3) those with epigaeic, endogaeic, and anecic earthworms including L. terrestris L. Species richness and diversity of litter- and soil-dwelling (0-2 cm soil depth) oribatid mites was 1-2 times higher in sites without earthworms. Litter-dwelling oribatid mites were between 72 and 1,210 times more abundant in earthworm-free sites. Abundance of litter-dwelling oribatid mite in sites without the anecic L. terrestris was twice as high in May and 28 times higher in October compared to sites with L. terrestris. The species compositions of both litter- and soil-dwelling oribatid mite communities of forests with no earthworms were markedly different from those with earthworms. We conclude that exotic earthworm invasions are associated with significant declines of species diversity and numbers, and compositional shifts in litter- and soil-inhabiting communities. These faunal shifts may contribute to earthworm effects on soil processes and food web dynamics in historically earthworm-free, northern temperate forests.

Are SPB Utilizing *Ips* Infested Trees during Intermediate and Latent Population Phases?

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The Southern Pine Beetle (SPB), *Dendroctonus frontalis* has been the most important native pest of southern yellow pine trees. Over the past 10 years, a steady decline in SPB populations and infestations has been observed. SPB can still be caught in Lindgren Funnel traps in Mississippi, however only a few small SPB infestations are reported each year. For decades, publications have hypothesized that SPB take advantage of *Ips* infested or lightening strike trees. Our objective was to quantify how frequently SPB co-inhabit *Ips* infested trees during this recent low SPB population phase. Seven Loblolly pine trees (*Pinus taeda*) infested with *Ips* engraver bark beetles (2 of which were lightening struck) were felled and bucked into 0.5 meter sample bolts. We used a proportional sampling scheme to select which bolts were brought back to the lab for rearing. We selected two 0.5 meter sample bolts from the lower/mid bole, two sample bolts from the upper bole, and three sample bolts from the upper crown. Samples were placed in 35 gallon rear-

ing cans for approximately six weeks. Emerged beetles were identified to species and counted on a weekly basis. A total of 3,375 *Ips spp.* were reared from the samples. Approximately 70% of *Ips avulsus* were reared from mid bole samples, 80% of *Ips calligraphus* were reared from lower bole samples, and *Ips grandicollis* were distributed relatively even throughout the lower, middle, and higher boles. Results support previous evidence of resource partitioning by bark beetles. No SPB were found in any samples, but their presence was confirmed in the vicinity using Lindgren funnel traps. The result generates questions regarding how successful low populations of SPB are at competing for hosts when *Ips* populations are high.

Building a Hazard Map of *Sirex noctilio* Fabricius in the Southeastern United States Using Host Preference Data

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We present a draft model of a hazard map that includes host preference data for the invasive woodwasp, *Sirex noctilio* Fabricius. Risk maps have been created for the United States of America displaying the potential spread of *S. noctilio*. Previous risk maps did not use host preference data because they were unavailable at the time of creation. The host species of *S. noctilio* are conifers of the genus *Pinus*. The proposed hazard map will incorporate new data regarding *S. noctilio* preference for southeastern pine species, and assess the potential spread and impact of the woodwasp using these new resources.

Effects of Winter Climate Change on Tree Physiology and Arthropod Diversity in a Northern Hardwood Forest

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Climate projections for the northeastern U.S. predict an increase in air temperatures and precipitation. The precipitation is projected to accumulate as rain rather than snow. This combination of changes in climate may result in reduced forest snowpack, thereby decreasing thermal buffering of the forest floor. Effects of increased soil frost on tree physiology and insect communities is not clearly understood. Ecological and physiological requirements of insect species can be narrow and therefore they may quickly respond to climatic disturbance. Ground-dwelling insects are one indicator of biodiversity. The purpose of this study is to simulate the delayed onset of the snowpack to evaluate tree and insect responses. Treatments included four vegetation removal plots, vegetation and snow-removal plots, and reference plots (each 13 x13m^2) at Hubbard Brook LTER. Treatments were repeated for three consecutive winters and we report results following the third year. Root damage and physiological response in sugar maple (Acer saccharum) were significantly impacted with increased soil freezing. Effects of soil freezing on the abundance of 13 genera of ground-dwelling insects is being quantified. The results of this research will provide information on tree and insect responses to projected winter climate change.

Assessing Susceptibility of Three Hymenopteran Parasitoids of EAB to the Entomopathogenic Fungi *Beauveria bassiana*.

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Emerald ash borer (Col: Buprestidae) is killing ash trees across 15 states and southeastern Canada. Integrated pest management using biological control appears to be the only viable long-term approach for controlling the spread of EAB. The objective of this study was to assess susceptibility of three Hymenopteran parasitoids of EAB, *Spathius agrili, Tetrastichus planipennisi,* and *Oobius agrili* to an entomopathogenic fungus, *Beauveria bassiana,* which infects and kills EAB adults when applied as a pre-emergent trunk spray. Adult EAB and parasitoids were exposed to *B. bassiana* inoculated ash twigs for two hours and then observed for death and signs of infection for up to ten days. All EAB adults exposed to *B. bassiana* were fatally infected while mean survival for control EAB was 76%. Mean survival in the treatment groups for *Tetrastichus* and *Spathius* were 98% and 86%, respectively, indicating these parasitoids are relatively unaffected by exposure to *B. bassiana*. Data for *Oobius* was inconclusive as parasitoids in neither the control nor treatment groups survived very long. This research elucidates interactions between two potential biological control agents and provides data necessary to developing a successful multi-stage integrated management approach to control of EAB.

Behavioral and Colonization Preferences of the European Woodwasp (*Sirex noctilio* F.) to Southeastern Pines

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Sirex noctilio, the European woodwasp, is an invasive insect that kills pine trees through a combination of larval galleries, phytotoxic mucus, and fungal growth. Newly established in Established populations in southeastern United States have yet to be found, although temperature surveys suggest the wasp will easily tolerate the southeast U.S. climate. The high number of ports of entry as well as large natural and commercial pine stands in the southeast U.S. raise concern over the probable expansion of the *S. noctilio* range into this area. However, little is known about the preferences of the woodwasp to southeast U.S. pines. Our research objectives were to 1) assess the preference of *S. noctilio* pines species present in southeast U.S. forests using colonization and progeny development bioassays and 2) utilize these bioassay results to provide host hazard maps for *S. noctilio* in southeast U.S. pine stands using geospatial techniques. A preliminary bioassay in 2009 was conducted with two species of southeast U.S. pine compared with Scots pine, a native host to *S. noctilio* that is naturalized in the northeast U.S. The study was expanded in 2010 to include six species of southeast pines, and in both 2009 and 2010 preference was measured by *S. noctilio* behavior in and on bolts. More *S. noctilio* females were observed drilling on Virginia and Scots bolts than on loblolly in 2009; this trend was the same in 2010. In both 2009 and 2010, no progeny was found in nor emerged from loblolly bolts. Only progeny and exit

holes from Scots, Virginia, and white pine were found in 2010. Together these data from bolts suggest that white, Scots, and Virginia bolts have both a higher rate of host acceptability and are perhaps more suitable hosts than loblolly, longleaf, shortleaf, and slash pines. At present, it is unknown how host resistance mechanisms may play a role in susceptibility of live trees in southeastern U.S. In 2010, physical and chemical wood property measurements including age, specific gravity, density and size of resin canals, and relative monoterpene composition were measured to control for known confounding factors and to possibly assist in explaining preference. Overall, we intend to geospatially reference these biological data with existing host density, type, and condition maps to provide recommendations for relative susceptibility of southeast U.S. pine stands to potential invasion and establishment by *S. noctilio*.

Is Whitebark Pine a Better Host for the Mountain Pine Beetle Than Lodgepole Pine?

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Outbreaks of mountain pine beetles (MPB) have been rapidly spreading across whitebark pine landscapes since the early 2000's. Based on the alarming speed of spread, whitebark pine may be a nutritionally superior host for MPB than lodgepole pine. This research examines the affects of whitebark and lodgepole tree host species on MPB emergence numbers and body sizes. Entrance and emergence hole counts were used to estimate brood emergence. Emergence cages were used to collect adults to measure body size. There was no difference in beetle emergence numbers between host species, but MPB emerging out of whitebark pine were larger than MPB emerging from lodgepole pine. These findings suggest that climate, and/or differences in tree defenses are larger drivers of beetle success in high elevations than nutritional differences between tree host species.

Phenotypic Heritability and Fecundity in *Ips pini* (Curculionidae: Scolytinae)

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Phloephagous insect herbivores in the family Curculionidae are ecologically and economically influential to many coniferous forests in North America. Because of their impacts of forests, considerable research has focused on their population dynamics and importance in natural resource management. Beetle fitness is a key factor in achieving stand-replacing population levels. Beetle size is often used as a proxy for fitness because it has a significant effect on the quality and quantity of breeding opportunities. We investigated parental influences on offspring phenotype in the secondary bark beetle, *Ips pini*. We tested the narrow-sense heritability of beetle size and its significance in fecundity through a controlled laboratory experiment using *Pinus ponderosa*. We examined the influences of parental beetle size and sex on progeny size, number of progeny, and oviposition gallery length. Beetle size was significantly heritable, as larger pairs produced longer galleries and larger offspring, and female size played a greater role in reproductive success than male size. Parental size did not affect reproductive output. Our results suggest there is an additive genetic component influencing beetle phenotype, which is an important element in understanding the internal dynamics of landscape-scale population eruptions.

Modeling the Potential North American Range of Redbay Ambrosia Beetle (*Xyleborus glabratus*) Based upon Cold Temperature Tolerance

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The redbay ambrosia beetle (RAB), *Xyleborus glabratus* Eichoff, a nonnative insect originating from eastern Asia, attacks tree species in the Lauraceae family. The first detection of the beetle in the United States occurred in 2002, near Savannah, Georgia. Since that time, the beetle has spread north into South Carolina, and south into Florida. Confirmed reports of infestation have been reported as far away as Mississippi. It is unclear if these beetles are part of the same phylogeny occurring along the Atlantic coast. What is also unclear is the minimum temperature the beetle can tolerate. As redbay populations decline along the Atlantic and Gulf coasts the beetle will seek out new hosts farther inland, such as sassafras (*Sassafras albidum*). The sassafras is of greatest concern because its habitat occurs immediately inland from redbay, along the eastern United States, and ranges into southern Ontario. We will experimentally determine the low temperature tolerance of the RAB in order to model its potential range into and across North America.

Biology and Oviposition Patterns of Arkansas *Sirex*

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Female *Sirex* (Hymenoptera: Siricidae) native to Arkansas were collected from felled pine logs (bolts) from the fall of 2009 through spring of 2011. Bolts were kept in rearing containers and females collected were exposed to 0.5 m pine logs with no treatment and 0.5 m bolts with artificial *Monochamus sp.* or *Xylotrechus* sp. (Coleoptera: Cerambycidae) oviposition pits in a 2^2 factorial design: two size classes of bolts, each with two densities of pits. Degree of aggregation of siricid oviposition drills was calculated using Lloyd's method of mean crowding. Polymerase chain reaction (PCR) was performed on cerambycid larvae found feeding on larval siricids as well as *Xylotrechus* adults found emerging from siricid rearing logs. A one-way ANOVA showed no difference in degree of aggregation between bolts with no treatment and bolts with artificial cerambycid pits (p=.6132). Mean crowding showed an aggregated distribution of drill holes with a negative binomial distribution. The sequence of the adult *Xylotrechus* showed an 82% match to *Monochamus.*

An Unrivaled Buprestidae Sampling Methodology: Evaluating Sampling Efficiency of the Buprestid Hunting *Cerceris fumipennis*

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The wide range of buprestid species caught by the digger wasp, *Cerceris fumipennis* Say (Hymenoptera: Crabronidae), has generated interest in using these wasps to sample for Buprestidae. To date, no sampling method has caught more species of buprestids as efficiently as *C. fumipennis*. We sampled five colonies over two seasons in New York catching 41 buprestid species. We looked at morphological and ecological traits of prey caught by this wasp for commonalities

that may explain prey choice. A comparison between historical museum records of buprestid beetles and beetles collected in 2009 and 2010 from New York was made to evaluate how effective the wasp is at capturing Buprestid diversity. Wasps caught 43% of the 42 buprestids species known from museum records in study areas, 23 buprestid species not present in museum records and three species of non-buprestid beetles. Based on average sizes of prey items caught, a 4.1 - 18.9 mm prey size range is proposed. Nearly all known beetles from study counties (98%) were captured within this size range, regardless of ecological factors when phenological data was considered. This research indicates that *C. fumipennis* is a reasonable candidate for buprestid sampling when beetle phenology and size are accounted for.

Interactions of the Walnut Twig Beetle, *Pityophthorus juglandis*, and the Fungus, *Geosmithia morbida*, in Thousand Cankers Disease of Walnuts in CA

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The walnut twig beetle (WTB), *Pityophthorus juglandis* Blackman, is a phloeophagous bark beetle that has recently been associated with a newly described fungus *Geosmithia morbida.* This insect-fungal complex, known as the thousand cankers disease (TCD), is fatal to walnut trees and is responsible for the decline of several species of black walnuts in the western United States over the past decade.

Thousand cankers disease poses a serious threat to native and introduced walnut species. In CA, walnut trees are integral parts of natural riparian forest ecosystems (*Juglans hindsii* & *J. californica*), favored as ornamentals, valued for timber, and harvested for their nuts (e.g., English or Persian walnut, *J. regia*). We seek to quantify the frequency and progression of TCD in various walnut species and regions within CA, assess the number of spores of *G. morbida* on individual WTB and the frequency of beetles with spores from various populations within CA, and compare the reproductive success of WTB in *J. regia* versus *J. hindsii* through colonization behavior and emergence density.

Phenology, Diversity and Parasitic Nematodes of Arkansas *Sirex*

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Although a secondary pest in its native range, *Sirex noctilio* F. (Hymenoptera: Siricidae) is a serious invasive pest throughout the southern hemisphere. In 2004, this species was discovered in New York but it has not yet been found in the southeast. Southern forests have a complex of wood-borers, bark beetles and natural enemies which have the potential to parasitize, prey upon and compete with *S. noctilio*. How native *Sirex* interact in this environment is unknown. The overall goal of our research is to determine the diversity and phenology of native *Sirex* and parasitic nematodes across Arkansas. Panel traps baited with Contech Inc. *Sirex* lures were erected in sites in three distinct forest environments: Ozark National Forest, Ouachita National Forest and Southern Arkansas Gulf Coastal Plain. Trapping results show flight times occurring from mid October to November. Trapped *Sirex* are dissected to determine if parasitic nematodes are

found in native *Sirex* and molecular diagnostics is being conducted to identify nematode species. Nematodes have been recovered from individuals from all three forests. This knowledge of native *Sirex* and associated nematodes could assist in detection and possible management of *S. noctilio* in the southeast.

***Sirex nigricornis* Oviposition: Response to Bark Thickness**

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Woodwasps in the genus *Sirex* (Hymenoptera: Siricidae) colonize xylem of stressed, dying and dead conifers. Adult wasps do not feed and therefore females must mate, locate a suitable host and deposit eggs with energy reserves acquired during larval development. Where female *Sirex* oviposit has a profound effect on their offspring's fitness. We wanted to determine if bark thickness affected oviposition preferences of a *Sirex* species occurring in Arkansas, *Sirex nigricornis*. To test this, gravid females were collected at the time of emergence and placed in cages that contained bolts of shortleaf pine on which half of the bark had been shaved down to a few mm above the phloem. Once all females in a cage died, the proportion of holes in shaved and unshaved portions of each bolt was calculated, arcsine transformed and analyzed using one-way ANOVA. Our results indicate that *Sirex nigricornis* prefer to oviposit in thin versus thicker-bark areas.

A Walk Through the Park: Host-Searching Behaviour of Warren Root Collar Weevil, *Hylobius warreni* Wood (Coleoptera: Curculionidae)

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Warren root collar weevil, *Hylobius warreni*, is a native insect that is transcontinentally distributed throughout the boreal forest of North America. In western Canada, the weevil's primary host is lodgepole pine, *Pinus contorta* var. *latifolia*. While adults inflict minimal damage upon their hosts, larval feeding can girdle young trees, potentially causing tree death. Klingenberg et al. (2010) found that the movement rates of Warren root collar weevil was elevated in forest stands with higher numbers of dead trees, consistent with a hypothesis that the insects were searching for live hosts. Very little is known, however, about host-searching behaviour or movement paths. We used harmonic radar to examine weevil movement in three habitats: a grassy field, at the edge of a forest, and within a forest. Weevils exhibited the highest initial movement rates away from stand edges. Findings from this study may aid in the development of management strategies aimed at reducing movement of Warren root collar weevils into plantations that are at high risk of weevil-induced mortality. Such plantations may become more numerous in the central interior of British Columbia due to landscape changes as a result of the mountain pine beetle epidemic.

Pests, Pathogens, and Predators Oh My: Factors Influencing Eastern Hemlock Vigor in the Chattahoochee National Forest, Georgia

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Since the discovery of the hemlock woolly adelgid (*Adelges* tsugae; HWA) in the north Georgia mountains in 2002, attempts have been made to preserve eastern hemlocks (*Tsuga* canadensis) at the southernmost edge of their range. In the Chattahoochee National Forest (CNF), approximately one million biological control beetles have been released to combat the HWA. Although preliminary, short-term results show no effect of biological control beetles on hemlock tree condition ($F = 0.26$; df = 1; $P = 0.622$), observations found additional factors that may be influencing hemlock vigor in the CNF: 1) Pathogens causing crown and tip dieback on hemlocks, including *Sirococcus tsugae* and *Phomopsis* sp., were found in multiple locations within the CNF resulting in upwards of 70% of an individual tree's tips being affected. 2) High temperatures (average daily temperature > 27°C) at lower elevation stands (< 460 m) appear to be correlated with higher HWA mortality and hemlock health in the CNF. 3) Other pests have been found within, or are threatening to invade, the CNF such as the Indian wax scale (*Ceroplastes ceriferus*), the elongate hemlock scale (*Fiorinia externa*), and the hemlock borer (*Melanophila fulvoguttata*). Future research will look at the effects and interactions of the HWA, predatory beetles, pathogens, temperature, and secondary pests on hemlock vigor to better interpret the future of eastern hemlocks in their southernmost range.

A Lucid Identification Tool to the Bark Beetle Genera of the United States

Javier E. Mercado

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Native Bark beetles are an integral component of forest ecosystems. Although they provide many beneficial services some species can cause significant ecologic and economic impacts to our forests. Port of entry personnel as well as foresters and students of this group, continually find new challenges with identifying beetles found in wood products and wooden packaging materials originating from throughout the world. Novel tools to facilitate identification of insects can prove to be very useful.

Aspen´s Life Experience Embedded in Physiology: Impact of Carbohydrate and Nutrients on Plant Chemistry and Insect Fitness

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The defensive aptitude of plants is ruled by genetic and environmental components. The interactions between biotic and abiotic stresses in plants infer about strategic allocation of plant resources and plant decision making. One of the challenges of the study of the interaction between defense and growth is to produce plants with different nutrient status. We subjected aspen seedlings to different conditions. As expected, this yielded aspens with different nutri-

ent status. Those seedlings were then subjected to forest tent caterpillars (Malacosoma disstria) defoliation to evaluate insect fitness on the light of the feeding experience.

Preliminary results showed that the caterpillar consistently fed on aspen seedlings with high carbohydrate and nutrient contents where as aspens with low such resources had little defoliation. Those observations are linked to leaf chemistry, both primary and and secondary defensive chemistry. Relationships are to be deduced between the leaf chemistry and the caterpillar development measured as average instar reached. The concentration of specific phenolic compounds known as deterrents of browsing is also to be assessed and correlated to the caterpillar growth. This study highlights the impact of variations in plant growing conditions, and their effects on plant physiology and chemistry, on insect herbivory.

Effect of *Formica aserva* Forel (Hymenoptera: Formicidae) Colonies on Ground Dwelling Arthropods in Central British Columbia

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Ground dwelling arthropods such as carabids (Coleoptera: Carabidae) and spiders (Araneae) may experience niche overlap with some ants based on occupation of similar ecological guilds. Several ant species develop large colonies with aggressively defended territories and may become dominant at various forest succession stages. The nature of interspecific interactions between ants and other arthropods in British Columbia is poorly understood. Interactions between these different groups may affect the nature of local coexistence, e.g., species exclusion may occur. Carabids and spiders have been examined as prospective biological indicators in forestry applications. Potential interactions between foraging ants with carabids and spiders may influence interpretation of disturbance effects on these assemblages. This research examines the relationships between *Formica aserva* Forel (*F. subnuda* Emery) and assemblages of carabids and spiders in a recently disturbed forest habitat east of Prince George, British Columbia, Canada. Nordlander type pitfall traps were used to assess the activity abundance of carabids, spiders, and *F. aserva*. An area with a relatively high density of observed *F. aserva* nests was compared to an adjacent area with no observed *F. aserva* nests. We will report how the presence of *F. aserva* may have influenced ground dwelling arthropod assemblages.

Differences in Preference and Performance of *Leptoglossus occidentalis* Heidemann (Hemiptera: Coreidae) on Conifer Hosts

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The western conifer seed bug, *Leptoglossus occidentalis* Heidemann (Hemiptera; Coreidae), is a serious pest of conifer seed production operations in the western United States and Canada. Potential impact across conifer species was evaluated using laboratory tests to measure suitability and preference of western conifer seed bug for cones from different conifer hosts commonly produced in western seed orchards. Adult *L. occidentalis* were placed in arenas with cuttings from several potential hosts (ponderosa pine, lodgepole pine, western larch and Douglas-fir)

and monitored for feeding and ovipositional activity. Adults were also placed in no-choice arenas with the two less-preferred hosts (western larch and Douglas-fir) and monitored for ovipositional activity. *L. occidentalis* nymphs were placed in arenas with no food, access to water only or one of several potential host cones (western white pine, ponderosa pine, lodgepole pine and Douglas-fir) and conelets (ponderosa pine, lodgepole pine). Nymphs were monitored for survival and maturation. There were significant differences among conifer hosts in adult feeding and oviposition activity, as well as percentage of nymphs surviving to adulthood. There were no significant differences in the maturation rate of nymphs among species.

Assessing *Eucryptorrhynchus brandti* (Harold) (Coleoptera: Curculionidae) as a Potential Carrier for *Verticillium albo-atru*m from Infected *Ailanthus altissima* in Three Quarantine Experiments

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Two potential biological control agents for the invasive tree of heaven (TOH), *Ailanthus altissima* (Mill.) Swingle, have been extensively studied: a native vascular wilt fungus, *Verticillium albo-atrum* Reinke & Berthold, and a host-specific weevil herbivore from China, *Eucryptorrhynchus brandti* (Harold), which is currently pending quarantine release. In 2002, *V. albo-atrum* was observed in Pennsylvania causing significant mortality to TOH. This fungus is highly virulent to TOH, however, long-range dissemination of this agent appears to be restricted. The purpose of our research is to determine if *E. brandti* can successfully carry and transmit *V. albo-atrum* to TOH. All quarantine lab assays were conducted using forms of passive transmission on different body localities from substrates that mimic a natural source of fungal infestation that may be present in the field. In one experiment, 75% of adult *E. brandti* were able to transmit *V. albo-atrum* after feeding and walking on infested plant material to TOH seedlings. Other studies include transmission by feces, and transmission by overwintering weevils in naturally infested potting mix.

Examining the Emergence Phenology of *Sirex noctilio* F., Native *Siricidae*, and their North American Parasitoid Complex in New York

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The invasive woodwasp, *Sirex noctilio*, has had devastating impacts on commercial pine plantations wherever it has been introduced in the southern hemisphere. Since its first detection in North America 5 years ago, it has been found in four states and two Canadian provinces. To develop phenological models for *S. noctilio,* native siricids, and their parasitoids, nine 0.5-meter bolts were removed from 30 red pine (*P. resinosa*) and Scot's pine (*P. sylvestris*) from 2 sites in central and western New York. Insects were allowed to emerge in rearing tubes in an outdoor insectary at ambient environmental conditions. Overall, 391 Sirex noctilio emerged along with 246 native siricids and 216 parasitoids. Phenologies indicate *S. noctilio* and the native siricids minimally overlap in their emergence while some parasitoids are emerging during the same period as the introduced woodwasp. Our results provide novel insights into this complex and set the

stage for further research into how our native community is responding to increased numbers of *S. noctilio*.

What Doesn't Kill You Only Makes You Stronger… Unless It Is More Bark Beetles

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Dendroctonus ponderosae (Hopkins) or mountain pine beetle is a native pholoeophagous herbivore generalist on more than 20 pines in western North America, but in British Columbia, the primary host is lodgepole pine (*Pinus contorta* var. *latifolia* Engelmann). As a primary bark beetle, *Dendroctonus ponderosae* kills its live-host, exhibiting profound landscape-level mortality, especially at the epidemic stage. As of 2011, *Dendroctonus ponderosae* has killed a total of 726 million cubic meters of timber, or an equivalent cumulative area of 17.5 million hectares of mature pines in British Columbia. The increase of dead trees was not fully utilized by mountain pine beetle because some portions of the host are not suitable for their growth and development, creating a niche of opportunity for the secondary bark beetles. There is a positive correlation between the number of dead trees with *Dendroctonus ponderosae* sympatric species, or the facultatively aggressive populations of secondaries, such as *Ips pini* (Say), *Pseudips mexicanus* (Hopkins), and *Orthotomicus latidens* (LeConte). At the post-epidemic stage, this study found that new pine mortality was associated with a complex of secondary bark beetles, and not *Dendroctonus ponderosae* as the main mortality agent in those stands; since at high population density, secondary bark beetles may sustain the outbreak by killing the smaller diameter live-residuals.

Effects of Soil Freezing on Biodiversity of Ground-Dwelling Insects and Terrestrial Snails in Northern Hardwood Forests

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The proposed research will focus on the effects of increased soil freezing due to reduced snowpack on species diversity of ground-dwelling insects and species and genetic diversity of terrestrial snails. Relative abundance and species composition of insects and snails will be examined in relation to soil temperature, soil calcium content, soil pH, soil frost depth, and density of vegetative cover. Ground-dwelling insects and terrestrial snails are attractive model systems because they are abundant in northern hardwood forests, easy to capture, and are highly sensitive to environmental change. Snails are a useful system for molecular study because of their life history and limited dispersal ability. The study sites, located at Hubbard Brook LTER, are dominated by sugar maple (*Acer saccharum*) and yellow birch (*Betula alleghaniensis*). We will measure insects and snails in four vegetation plots, four vegetation and snow-removal plots, and four reference plots (each 13 x13m^2). Reference plots will facilitate measurement of population level differences in snail and insect populations. As ground-dwelling insects and terrestrial snails are vital faunal components of terrestrial ecosystems, understanding the effects of soil freezing on biodiversity of these two groups will further our understanding of how winter climate change affects forest ecosystems.

Student Poster Session – Ph.D. Students

Ph.D. Poster Competition -- Award Recipients

First Place: Abdul Hakeem (University of Tennessee)

Second Place: Vanessa Lopez (University of California at Riverside)

Sugar Maple Dieback in the Northwestern Great Lakes Region

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Unusually high levels of sugar maple (*Acer saccharum*) dieback have recently been reported throughout the Upper Great Lakes Region. The etiology of this dieback is unclear; however, it is most likely attributed to a combination of edaphic and climatic factors, and management impacts in some areas. A network of 120 plots has been established in Upper Michigan, Northern Wisconsin, and Eastern Minnesota on both private industry and public lands to evaluate the range, progression, and factors associated with the sugar maple dieback. General plot assessments were conducted along with stem and canopy assessments on all trees within the plots. Foliage, soil, and tree growth cores have been collected from half of the plots to examine the available nutrients and growth of trees, and to characterize relationships among nutrient status, climate, and other growth disturbing events. Initial sugar maple dieback of all plots during summer 2010 was 14.4% with the average plot dieback ranging from 75% to 3% in a stand. Initial results from nutrient analysis indicate that many plots have below normal range levels reported in literature for many cations in the foliage and soils. Growth also appears to have been declining for decades in trees currently exhibiting high levels of dieback.

Comparing Host Plant Resistance to the Balsam Woolly Adelgid (*Adelges piceae*) in Three Fir (*Abies*) Species

David Bednar, Fred Hain, John Frampton, Allen Cohen, Sergei Krasnyanski, and John King

North Carolina State University, Raleigh, NC

We are comparing variations in host plant resistance to the invasive insect *Adelges piceae* (BWA) within and among three fir species. Limited resistance to BWA has been observed in natural populations of Fraser fir (*Abies fraseri*), while complete tolerance and resistance has been tested in Turkish (*A. bornmuelleriana*) and Veitch (*A. veitchii*) fir (respectively). The mechanisms for the putative resistance observed have yet to be revealed. We hope to elucidate the differences between species using metabolic analysis, coupled with behavioral assays, and observations of feeding behavior in order to better understand this interaction. Our overall goal is to uncover the basis for resistance in these fir species, to incorporate them into an improved breeding program and help alleviate the costs of chemical control.

The Mountain Pine Beetle as a Model of Parapatric Speciation?

Ryan R. Bracewell

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Understanding speciation amounts to understanding the evolution of reproductive isolation. Recently, a reproductive barrier has been discovered in the mountain pine beetle (*Dendroctonus ponderosae*) that is located geographically between the states of Oregon and Idaho. Population crosses close to this boundary produce hybrid males with reduced fecundity (ID x OR), and distant crosses (ID x southern CA) produce sterile males. Reproductive problems originating in the hybrid male are considered to be the first incompatibilities to arise during speciation. Here, I further investigate the apparent geographic boundary between Oregon and Idaho by crossing beetles of an intermediate geographic distance (with respect to the Oregon/Idaho boundary) and test the reproductive output of hybrids. Consistent with crosses close to the boundary, only one direction of the cross appears to produce compromised hybrid males; however, a large proportion of hybrid males are completely sterile. Females recovered from matings with sterile hybrid males show evidence of motile sperm in their reproductive tract, although the quantity of sperm appears reduced. These results suggest that geographic distance from the Oregon/Idaho zone differentially impacts the hybrid male, and demonstrate a progression of reproductive incompatibilities consistent with predictions rooted in evolutionary biology and speciation theory.

Post-Release Evaluation of *Laricobius nigrinus* for Biological Control of Hemlock Woolly Adelgid in the Eastern United States

Gina A. Davis, Scott M. Salom, Loke T. Kok, Carlyle C. Brewster

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Laricobius nigrinus is one of several predators introduced into the eastern United States for the biological control of hemlock woolly adelgid (*Adelges tsugae*). Over 120,000 adult beetles have been released in 15 eastern states and populations are established in at least 11 states. The efficacy of *Laricobius nigrinus* was evaluated by (1) comparison of predation at two paired release and geographically separated non-release sites (control) from 2008 through 2010, (2) comparison of predation at those two eastern release sites with the averaged predation observed at three sites within the endemic range of *L. nigrinus* and *A. tsugae* (i.e. Seattle, WA), and (3) a measure of hemlock health at the time of *L. nigrinus* release and again up to seven years post-release at 12-paired release and control sites. At the two study sites in the eastern United States there was a trend for lower survival rates of *A. tsugae* and higher ovisac disturbance on release trees when compared with paired control trees. Yet, *A. tsugae* density remained significantly higher on release trees (= 2.6 ± 0.5 SE) than on control trees (= 1.5 ± 0.3 SE). *A. tsugae* density explained the greatest amount of variation between the release and control trees in a multivariate analysis of variance ($F_{4,51} = 4.008$, $P = 0.007$), which evaluated predation as a function of *A. tsugae* density, survival rate, percent of disturbed ovisacs, and the average number of adelgid eggs/ovisac. Densities of *Laricobius* and *A. tsugae* in the East were predominantly within or above a 95% confidence range observed in Seattle, WA, while the predator-prey ratio remained much lower in the East (0.007 to 0.047) than observed in Seattle, (95% CI, 0.112 to 0.272). Hemlock health was measured by foliage transparency (percent of light penetrating the crown) the year of *L. nigrinus*

release and again in 2010. At the time of beetle release (2003 to 2005), the averaged foliage transparency was 55% for trees at the 12-paired release and control sites. Remeasured in 2010, the averaged foliage transparency was 61% for trees at both release and control sites. Predation by *L. nigrinus* at the sites evaluated in this study was not enough to reduce and regulate *A. tsugae* densities to levels observed in Seattle, WA or prevent hemlock health from declining within seven years post-release. The actual efficacy of *L. nigrinus* may not have been captured because the release locations in this study were established by experimental release strategies and samples were only taken from the release trees. Since the completion of this study improvements have been made to release strategies by implementing more stringent site selection criteria, increasing release size in the warmer climates and using a more cold tolerant *L. nigrinus* biotype in cooler climates. Future evaluations are merited to capture the dynamic predator-prey interactions with observations made on hemlocks throughout the targeted stand.

Interactions between the Yeast *Ogataea pini* and Filamentous Fungi associated with the Western Pine Beetle

Thomas Seth Davis, Richard W Hofstetter, Jeffrey T Foster, Nathaniel Foote, Paul Keim

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We tested six monoterpenes on O. pini biomass growth in vitro and found that most monoterpenes inhibited O. pini growth; however, mean O. pini biomass increased 21.5% when treated with myrcene and 75.5% when treated with terpinolene, relative to control. Ogataea pini was grown on phloem tissue ex vivo to determine if O. pini affected phloem chemistry. Monoterpene concentrations declined in phloem over time, but phloem colonized by O. pini had significantly different concentrations of monoterpenes at two time periods than phloem with no yeast. After 7 d, when O. pini was present, concentrations of the monoterpene Δ-3-carene was 42.9% lower than uncolonized phloem, and concentrations of the monoterpene terpinolene was 345.0% higher than uncolonized phloem. After 15 d, phloem colonized by O. pini had 505.4% higher concentrations of α-pinene than uncolonized phloem. These experiments suggest that O. pini responds to phytochemicals present in host tissues and the presence of O. pini may alter the chemical environment of phloem tissues during the early stages of beetle development.

The Use of Near-Infrared Spectroscopy in Detecting Imidacloprid in Eastern Hemlocks in the Southern Appalachians

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Detection and determination of imidacloprid concentrations in eastern hemlock are limited to a few methodologies, which can be costly and time consuming. An experiment was established to evaluate the use of near-infrared spectroscopy for detecting and predicting imidacloprid concentrations in needle tissue and sap. Data obtained from branch samples suggest that near-infrared spectroscopy can offer a relatively inexpensive and less time consuming method for detecting the presence and determining concentration ranges of the insecticide in the needle tissue and sap of eastern hemlock. In-field testing for concentrations of imidacloprid are nonexistent, the use of near-infrared spectroscopy as a means to detect ranges of imidacloprid in the field are discussed.

Lacewings as Augmentative Biological Control Agents in Christmas Tree IPM

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Lacewing larvae are known to be voracious predators of many insects including aphids and their kin. The golden-eyed lacewing (*Chrysopa occulata*) occurs naturally in Fraser fir stands in the southern Appalachian mountains of North Carolina. Coupled with the common green lacewing (*Chrysoperla rufilabris*), our goal is to test the efficacy of these native, generalist predators against the Balsam wooly adelgid (BWA) on Fraser fir trees. Determining the functional response of both species on BWA, observing their search and feeding behavior, and categorizing the rate of cannibalism and food preference are of prime concern. The aim in doing so is to elucidate the effect of intraguild predation on both species of lacewings. Additional goals include the development of an artificial diet and rearing protocols for *C. occulata*, characterization of adult predation of BWA by *C.* occulata, and testing of a backpack bio-sprayer for direct application of lacewing eggs to the bole of BWA-infested Fraser firs.

Factors Influencing Establishment of *Sasajiscymnus tsugae*, a Predator of Hemlock Woolly Adelgid, in the Southern Appalachians

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In the southern Appalachians, eastern hemlock, *Tsuga canadensis* (L.) Carrière, is threatened by the hemlock woolly adelgid, *Adelges tsugae* Annand (Hemiptera: Adelgidae). In 2002, a biological control program was initiated against this invasive insect pest in the Great Smoky Mountains National Park. Since 2002, ca. 500,000 *Sasajiscymnus tsugae* (Sasaji and McClure) (Coleoptera: Coccinellidae), a predatory beetle native to Japan, were released in more than 200 sites in the Park. Of these release sites, 56 sites were sampled using beat-sheets for four-man hours per site from 2008-2010. *S. tsugae* was recovered from 17.86% of the release sites sampled in the Park. A suitable site-predictive model was developed using biotic, abiotic and climatic factors. Non-parametric Spearman's rank correlation indicated an inverse relationship between recovery of *S. tsugae* and year of release. Establishment of *S. tsugae* was significantly associated with older release sites with the most beetles recovered from 2002 release sites. These findings indicate that *S. tsugae* require more time for population densities to reach readily detectable levels. Minimum winter temperature was also significantly associated with establishment of *S. tsugae.*

Insect Response to Prescribed Burning, Harvesting and Wildfire in Pine Forests in the Upper Peninsula of Michigan

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The Muskrat Lakes and Sleeper Lake Fire sites in Michigan's Upper Peninsula represent an opportunity to investigate the impacts of prescribed fire and wildfire on forest health in the fire-adapted species red pine, *Pinus resinosa*. At the Muskrat Lakes Fire/Fire Surrogate Site, treatments included harvesting only, prescribed fire only and a combination of prescribed fire and harvesting, as well as untreated controls. Prior to treatment application, signs of red turpentine beetle (*Dendroctonus valens*) attack were rare. After treatments (2007-2008), the proportion of standing live trees attacked by red turpentine beetle in study plots was significantly higher in the burned treatment areas than the harvest only or control. A similar plot network was installed on the Sleeper Lake Wildfire site, a lightning-ignited wildfire that burned 7,365 hectares (18,200 acres) in August 2007. Flight intercept traps measured insect activity in burned and unburned red and jack pine (*Pinus banksiana*) stands. Sticky traps were used to assess landing behavior on individual scorched red pines. An increase in *Ips pini* activity was also observed following the wildfire. These studies can be used to advise managers about the strengths and limitations of prescribed fire as an analog of wildfire in this forest type.

Naturalization of *Alliaria petiolata* and its Effects on Interactions and Distribution of Associated Invertebrates

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What happens between invasive species establishment and recognition of invasiveness has been identified as a key research question that needs further exploration in the literature. The population dynamics and spread of these species into new areas likely depend broadly upon their community ecology, including relationships with native relatives and the associated suite of invertebrate pollinators, antagonists, and predators. Sites in Vermont containing populations of the invasive plant garlic mustard *(Alliaria petiolata*) and its native relative toothwort (*Cardamine diphylla*) will be selected and surveyed in the summer of 2011. We will conduct surveys at all sites twice per month to identify invertebrate pollinator and predator communities using common insect trapping techniques including sweep nets and malaise traps. Once all invertebrates are identified, the Shannon-Weaver index will be used to analyze species richness (*H'*) and evenness (*J*) in relation to plant type, plant density, plant reproductive status, understory light availability, and soil properties. Richness and evenness will be compared among all invertebrate species and within the specific feeding groups of insects. This study will provide empirical data for invasion ecology based on community ecology theory.

Feeding Response of Native Subterranean Termites to Wood Inoculated with Bark Beetle Pheromones and Blue-Stained Wood

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The interactions of bark beetles and subterranean termites are largely unstudied despite the economic and ecological importance of both. Subterranean termites are known to be attracted to wood decay fungal extracts. However, feeding preference of termites for wood containing

bark beetle pheromones and malanistic fungal associates of bark beetles is undescribed. A series of AWPA E1-09 "choice tests" were employed to determine the feeding preference of R. flavipes for blue-stained sapwood, sapwood inoculated with various bark beetle pheromone components, and combinations of blue-stained sapwood and pheromone components. Results indicate a feeding preference for both air-dried and kiln-dried blue-stained sapwood, unstained kiln-dried sapwood treated with frontalin, and air-dried blue-stained wood treated with frontalin and *endo*-brevicomin. The feeding preference of native subterranean termites for sapwood containing bark beetle pheromone and fungal associates may indicate that termites have adapted to identify utilize resources created by bark beetles.

Determining the Fecundity and Longevity for the Invasive Goldspotted Oak Borer (*Agrilus auroguttatus* Schaeffer) (Coleoptera: Buprestidae)

Vanessa Lopez and Mark Hoddle

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The goldspotted oak borer (A*grilus auroguttatus*) is a buprestid beetle which is native to oak woodlands in southeastern Arizona, and northern Mexico. Since its introduction into southern California, *A. auroguttatus* has caused widespread injury and mortality to three species of native California oaks; coast live oak (*Quercus agrifolia Née*), canyon live oak (*Q. chrysolepis* Liebm.), and California black oak (*Q. kelloggii* Newb.). Since 2002, tree mortality from *A. auroguttatus* has been estimated at >21,500 trees and this number is increasing rapidly as GSOB populations build and this pest spreads. Understanding the life history traits for this invasive beetle is invaluable for developing an efficient classical biological control program. Preliminary biological studies were conducted to determined the number of eggs females can oviposit throughout their lifespan when provided with food, water, and access to either one or two males. The longevity of female and male adults was also recorded the under the same laboratory conditions.

Host Choice of Mountain Pine Beetle in Response to Local Insect Population Density and Host Availability

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The mountain pine beetle outbreak in British Columbia, Canada, has currently caused severe lodgepole pine mortality across 40 million acres of forest. Lodgepole pine is the preferred host species of mountain pine beetle in British Columbia. However, there has been a recent increase in the occurrence of mountain pine beetle attack on interior hybrid spruce in areas that have experienced severe lodgepole pine mortality. This study tests the hypothesis that host specificity declines with increasing insect population pressure and decreasing host availability. We examined the attraction of mountain pine beetle to pine vs. spruce logs within central British Columbia as a function of local (i.e., within-stand) insect population pressure, and pine vs. spruce availability. The importance of these factors on mountain pine beetle host selection was tested under simulated "pioneering" and mass-attack conditions. Results indicate that pioneering mountain pine beetle are highly discriminating towards the preferred host, lodgepole pine, and are not influenced by the availability of spruce within a stand. When logs were baited with aggregation pheromones, however, mountain pine beetle preferred the species of host that was

most prevalent within a stand. As population density increased, the insects appeared to shift their preference toward pine hosts, suggesting that host specialization may actually be enhanced at high densities. Increasing host fidelity at high population densities may contribute to positive feedback in outbreak population dynamics.

Mapping Defoliator and Bark Beetle Impacts on Tree Mortality, Fuels, and Subsequent Wildfire in the Pacific Northwest Region

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Forest insects are important disturbance agents, and mapping their impacts is an active research frontier. This poster presents a retrospective, natural experiment that combines field, aerial survey, and satellite observations to investigate insect effects on tree mortality, fuels, and subsequent wildfires. We compare two prevalent insect agents (defoliator: western spruce budworm *[Choristoneura occidentalis]* vs. bark beetle: mountain pine beetle *[Dendroctonus ponderosae]*). We leverage field measurements at federal inventory plots to evaluate Landsat TM/ETM+ spectral trajectories since 1985 and cumulative insect damage maps from forest health aerial detection surveys (ADS) since 1980. Initial results indicate that Landsat-based maps capture insect-caused tree mortality and coarse fuel accumulation, complementing the ADS maps. In the Landsat time series, insect activity appears as combinations of gradual and abrupt vegetation decline and recovery, making it crucial that insect mapping methods capture a wide range of potential signals. Ongoing analyses will assess the role insects play in the spatiotemporal patterns of wildfires throughout the Pacific Northwest. Given the likely increase of both disturbances in western North America, the accurate characterization of insect effects on tree mortality, fuel profiles, and fire hazard will become increasingly important.

Insertion Site Selection and Feeding by the Hemlock Woolly Adelgid: Implications for Host-Plant Resistance

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The hemlock woolly adelgid (HWA; *Adelges tsugae* Annand) is an exotic insect causing widespread mortality of hemlocks in eastern North America. Of the nine hemlock species worldwide, the two in the eastern US (*Tsuga canadensis, T. caroliniana)* are the only trees which succumb to the infestation. Although literature indicates they are wholly susceptible, both anecdotal evidence and research implies intraspecific variation occurs; sources of this resistance are unknown. This research investigates mechanisms of resistance by comparing the physical characteristics of the hemlock species and studying HWA feeding behavior. Using low temperature-SEM, we found trichomes do not play a role in resistance, but the cuticle thickness at stylet insertion point may. In addition HWA has dentitions on its maxillary stylets, likely used to penetrate the cuticle in a saw-like fashion or to anchor HWA onto the plant. Using an enzyme assay, we determined HWA possesses protease, indicating that proteins are digested as part of their diet. Although it is unknown whether this occurs in the gut or the salivary glands, it may have implications for host response or resistance.

Quantifying Arthropod Diversity in the Selkirk Mountains of Northern Idaho and Eastern Washington

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The University of Idaho, in conjunction with Idaho Department of Fish and Game and the United States Forest Service seeks to quantify biodiversity within the Selkirk Mountain Range of Northern Idaho and Western Washington. The area contains the only known population of woodland caribou remaining in the lower forty-eight contiguous states and has been hypothesized to represent a refugium for cold-adapted species of invertebrates. As part of this project, beetle populations have been surveyed using pitfall traps and Lindgren funnel traps. The primary taxa of interest are ground beetles (Carabidae), but a full description of all insect species will be completed. Additionally, gastropod populations are being captured and identified due to the lack of data available on this group and their contributions to the overall diversity within the terrestrial invertebrates. In addition to providing a measure of biodiversity at several trophic levels, the completed project will quantify beetle and gastropod populations through time and space; this will allow researchers and managers to identify related and sensitive areas with regard to potential species of concern within the study area. These data will also allow for analysis of effects on populations by: land management activities, remoteness of sample unit, relationship to both flora and macro-fauna communities, and weather conditions, among others. Though still in its early stages, preliminary data will be presented for discussion.

Assessing the Survival of the Redbay Ambrosia Beetle and Laurel Wilt Pathogen in Wood Chips

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University of Florida, Gainesville, FL

Laurel wilt (LW) is a tree disease, which was first identified outside of Savannah, GA in 2003. It is thought that the fungal pathogen and its vector entered the U.S. prior to 2002 and spread into the local forests. The fungus which causes the wilt is *Raffaelea lauricola* (T. C. Harrin., Aghayeva, & Fraedrich) and it is vectored by the exotic redbay ambrosia beetle (RAB) *Xyleborus glabratus*, (Eichhoff, Coleoptera: Curculionidae). Typical of ambrosia beetles, RAB feeds on symbiont fungi and *R. lauricola* is one of several found in the beetle's mycangia. The fungus is related to another exotic tree pathogen, *Ophiostoma novo-ulmi*, causal agent of Dutch elm disease.

As of November 2010, LW occurs in 26 of Florida's 67 counties, 30 Counties in Georgia, and 13 Counties in South Carolina. Disease spread has been more rapid to the south than it has to the north and west. However, two recently-discovered outbreaks in Bay County, FL and in Jackson County, MS occur far beyond the limits of LW's previous range. These introductions were likely due to the anthropogenic movement of firewood or other untreated wood products.

As of yet, there are very few options for controlling the fungus or beetle. Questions regarding the post-removal and disposal of wood have led to this study. Our objective was to examine the survival of the *X. glabratus* and *R. lauricola* in chipped dead redbay trees.

Semiochemical Influence of Bark Beetles (*Dendroctonus frontalis*, and *Ips*) and Host Monoterpene (α-pinene) on Insect Community Associates

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The role of semiochemical communication in bark beetle behavior is well documented. However, the role of bark beetle semiochemical communication in the development of subcortical insect communities remains relatively unknown. In 2010, bark beetle communities were evaluated in the Oconee National Forest in Georgia. Response to lure combinations of frontalin (*Dendroctonus frontalis* attractant), ipsdienol and ipsenol (ips beetle attractants) and host synergist, α-pinene, were examined using baited funnel traps. Lure combinations included: frontalin and α-pinene; ipsenol and ipsdienol; frontalin, α-pinene, ipsenol and ipsdienol; and an unbaited control. *Dendroctonus frontalis* catches were highest with frontalin and α-pinene; which may reflect avoidance behavior of *D. frontalis* to hosts colonized by ips beetles. *Ips avulsus* and *Ips grandicollis* were consistently collected within each treatment type. However, traps baited with frontalin had decreased *I. avulsus* captures; demonstrating antiaggregant behavior incited by *Dendroctonus* aggregate pheromones. *Dendroctonus terebrans* was consistently captured; suggesting utilization of ipsenol, ipsdienol, α-pinene, and frontalin in host recognition. Trap catches of *Temnochila virescens* and *Thanasimus dubious* (known primary predator of *D. frontalis)* increased when ips lures were included with frontalin and/or α-pinene lures. Ips lures alone did not attract either predator; suggesting ips semiochemicals or host monoterpenes are needed to enhance predator attraction. *Aulonium ferrugineum* and *Monochamus titillator* responded similarly to treatments.

The Sound and the Scurry: The Influence of Sound on a Hemipteran Pest, *Cimex lectularius*

Kasey Maria Yturralde and Richard W. Hofstetter

School of Forestry, Northern Arizona University, Flagstaff, AZ

Very little is known about the potential for acoustic communication in bed bugs or the use of sound as cues in host location, though many hemipterans are known to communicate with sound. Most research has focused on bed bug pheromones, which are used in aggregation and as alarm signals. This knowledge gap is analogous to that of bark beetles, in which most research and management efforts have been focused on their use of pheromones and kairomones in aggregation and host tree selection. We investigated the production of sound in bed bugs, *Cimex lectularius*, and the influence of sound as a deterrent and/or an attractant, either of which could ultimately be used to monitor and control bed bugs. We presented airborne and substrate-borne sounds to bed bugs in no-choice and choice tests using an acoustic bioassay arena. Bed bugs were tested individually and in groups to control for the potential influence of aggregation behaviors. The results of behavioral assays and their implications for management will be discussed. Our research on acoustics in bed bugs is the first step in the potential development of a novel, non-toxic method to control an insect pest that has widespread economic and psychological impacts on humans.

Regular Poster Session

(posters are listed in alphabetical order by first author's last name)

Classical Biological Control of Emerald Ash Borer: Developing a Management Plan for Recovery of *Fraxinus* in North America

Leah Bauer[1], Juli Gould[2], and Jian Duan[3]

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The emerald ash borer (EAB), *Agrilus planipennis,* an invasive buprestid native to northeast Asia, has killed tens of millions of ash (*Fraxinus* spp.) trees in North America since its accidental introduction during the 1990's. To conserve native ash trees, we are evaluating classical biological control as a sustainable EAB-management method in forested areas of the United States.

In northeastern China, we found three parasitoid species that attack EAB: *Oobius agrili* (Encyrtidae), a solitary parthenogenic egg parasitoid; *Tetrastichus planipennisi* (Eulophidae), a gregarious larval endoparasitoid; and, *Spathius agrili* (Braconidae), a gregarious larval ectoparasitoid. After several years of research, our data was compiled into an Environmental Assessment and posted on the Federal Register for public comment: "Proposed Release of Three Parasitoids for the Biological Control of the Emerald Ash Borer in the Continental United States." APHIS' "Finding of No Significant Impact" and supporting documents and public comments are posted at: http://www.regulations.gov/fdmspublic/component/main?main=DocketDetail&d=APHIS-2007-0060

In July 2007, USDA APHIS and the State of Michigan approved release of these three species in MI. The first releases were done by Forest Service and APHIS scientists of *O. agrili* and *T. planipennisi* reared in E. Lansing, MI and *S. agrili* in Otis, MA. During the next two years, additional release sites were started in OH, IN, IL, and MD. An APHIS insect-rearing facility in Brighton, MI now produces these parasitoids for release in the U.S., and parasitoid-release sites were started in other infested states. We have confirmed that one or more of the three parasitoid species is established at release sites in MI, IN, OH, IL, and MD, however, ash tree mortality was similar in our release and control plots in MI and OH. We are now planning to evaluate the long-term impact of EAB biocontrol on ash tree recovery from saplings and seedlings at these field sites.

Soapberry Borer, *Agrilus prionurus* (Coleoptera: Buprestidae): Attack Characteristics and Known Distribution of an Invasive Pest of Western Soapberry

Ronald F. Billings, Donald M. Grosman, and Herbert A. Pase III

Texas Forest Service

The soapberry borer (*Agrilus prionurus,* Coleoptera: Buprestidae), a native of Mexico, was first reported in Travis County, Texas, in 2003 infesting western soapberry (*Sapindus saponaria* var. *drummondii*). As of March 2011, infestations of this invasive pest have been detected in 44 counties, extending from the Gulf Coast to the Texas-Oklahoma border. As its populations expand rapidly in Texas, this buprestid is killing all sizes of soapberry trees > 2 inches DBH. It may

eventually threaten western soapberry populations throughout the tree's range, which extends from northern Mexico to Missouri, and west to Arizona.

Infestations of soapberry borer are similar to those of emerald ash borer, *Agrilus planipennis*, a close relative not yet found in Texas. Infested trees can be easily recognized by the exposed sapwood that results when birds and squirrels chip off the bark to feed on the larvae. Bark chips accumulate at the base of the tree. A heavily-infested tree will die from the top down and exhibit numerous epicormic sprouts.

The adult beetle is about ½ inch-long, shiny black, and distinctively marked with four small white spots on the elytra. Larvae are flat-headed wood borers that may attain an inch or more in length as they mature. After feeding beneath the bark, the larvae bore into the wood to complete development and to pupate. The adult leaves a D-shaped exit hole as it emerges.

Western soapberry appears to be this insect's sole host in Texas and the tree exhibits little resistance to this introduced pest. The insect appears to have no more than one generation per year with adults emerging from late May to August. Methods of prevention and control are under investigation. The systemic insecticide emamectin benzoate (EB) is showing promise as a means to protect soapberry trees from infestation and/or save those trees in early stages of attack.

Mountain Pine Beetle Range Expansion: The Potential Impact of Insect Phenology

Kathy Bleiker, Greg Smith and Barry Cooke

Natural Resources Canada, Canadian Forest Service, Pacific Forestry Centre, Victoria, BC

The historic range of mountain pine beetle (MPB) in northern Canada has been limited to west of the Rocky Mountains in British Columbia (BC). During the recent epidemic in BC, large numbers of beetles breeched the Continental Divide and are now invading north-eastern BC and north-central Alberta. Insect survival, phenology and productivity appear to be highly variable in the new range. Complex phenology may affect the ability of the MPB to survive, aggregate and reproduce and ultimately its eruptive and spread potential in Canada's boreal forest. In the summer of 2010, we initiated a study that quantifies variation in MPB development and survival in addition to fine-scale under-bark and under-canopy temperatures in three geographic regions (historic range: southern and north-western BC; recently-invaded range: north-eastern BC and north-central Alberta). The study is currently part way through year 1 of the three year project.

Factors Influencing Northern Spruce Engraver Colonization of Slash in Interior Alaska

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The northern spruce engraver (NSE), *Ips perturbatus* (Eichhoff), is distributed throughout the boreal region of North America and is the primary mortality agent of white spruce in recently

disturbed areas (e.g., following wildfires, windthrow, timber harvests, and construction of fuel breaks, rights-of-way, roads, housing sites and pipelines). When favorable climatic conditions coincide with large quantities of suitable host material (e.g., slash), NSE populations may erupt, resulting in the mortality of apparently-healthy trees over extensive areas. Little work has been done to determine the effects of commonly used slash management practices on NSE performance in slash, and on the effectiveness of these practices for minimizing associated levels of tree mortality in residual stands. The objectives of this study are to determine the effects of slash scoring (mechanical by chainsaw or none), slash distribution (scattered versus decked), and cutting date (spring/summer versus summer/fall) on NSE colonization of and reproductive performance in white spruce slash; and to determine the effects of slash management treatments on adjacent levels of *Ips*-caused tree mortality.

Development of High-Resolution Pine Density Maps for Landscape-Level Modeling of Mountain Pine Beetle

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A classic issue in landscape ecology is the prediction of current and future distributions of plant and animal species at spatially-relevant scales. Spatially explicit predictions for phytophagous insect species such as the mountain pine beetle will require spatially-explicit information on the distribution of host-plant species. We use four vegetation datasets derived from satellite imagery and ground plot information to create fine-scale (30m) pine density data that can be used to drive spatially-explicit models for predicting the pattern of mountain pine beetle impacts across a landscape.

Biological Comparisons between the Progeny of Wild and Domestic Strains of *Sasajiscymnus tsugae*, a Widely Released Predator of Hemlock Woolly Adelgid

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{No abstract provided.}

Quantifying Impacts from Mountain Pine beetle Outbreaks

Christopher J. Fettig[1], Stephen R. McKelvey[1], A. Steven Munson[2], Kenneth E. Gibson[3], Carl L. Jørgensen [4], Jose F. Negrón[5], and Brytten E. Steed[3]

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Bark beetles influence forest ecosystem structure and function by regulating certain aspects of primary production, nutrient cycling, ecological succession and the size, distribution and abundance of trees. Mountain pine beetle (MPB), *Dendroctonus ponderosae* Hopkins, outbreaks have

been widespread across the western U.S. in recent years resulting in significant tree mortality in forests dominated by lodgepole pine. This study assesses ecological impacts of MPB outbreaks, and will aid in the development of resource strategies that address current and future forest conditions.

Twenty-five 0.08-ha circular plots were established in each of five states (CO, ID, MT, UT, WY) in areas of recent MPB-caused tree mortality. Aspect, elevation, slope and coordinates were recorded at plot center. Within each plot, all trees ≥7.6 cm dbh were tagged with species, dbh, height, height to base crown, status (live or dead), and year since death recorded. Three 16.1-m Brown's transects were established at 0°, 120° and 240° from plot center to estimate surface fuels (Fig. 3). A 1-m^2 plot was established at the end of each Brown's transect (n = 3/plot) to determine forest floor composition, and a 0.004-ha plot was established at plot center to estimate tree regeneration. Increment cores were collected from the three tallest lodgepole pines on each plot (N = 375) to determine stand age and site productivity. Data analyses are ongoing. All plots will be visited annually to record new tree mortality; to determine fall rates of trees; and to measure changes in fuel loads.

The New "Invasives and Threats" Team at the Pacific Southwest Research Station

Christopher J. Fettig[1], Richard F. Hughes[2], Nancy E. Gillette[3], Constance I. Millar[3], and Steven J. Seybold[1]

USDA Forest Service, Pacific Southwest Research Station, location at: [1]Davis, CA, [2]Hilo, HI, and [3]Albany, CA

USDA Forest Service Research and Development (R&D) works at the forefront of science to support the Agency's mission to "sustain the health, diversity and productivity of our Nation's forests and grasslands to meet the needs of present and future generations." The Pacific Southwest Research Station (www.fs.fed.us/psw/) conducts R&D in California, Hawaii and the U.S.-affiliated Pacific Islands, which is arguably the most biologically-, physically-, and culturally-diverse region administered by the USDA Forest Service. The ecosystems of this region provide critical goods and services, but are threatened by, among other factors, native and non-native invasive species, land-use changes, climatic changes, and sea level rise and ocean encroachment. Scientists in the recently formed Invasives and Threats Team of the Ecosystem Function and Health (EFH) Program lead research that provides an integrated understanding of ecosystem function and health, and of the biophysical conditions that threaten ecosystem resiliency.

The Western Bark Beetle Research Group – Basic and Application-Motivated Research That Enhances Scientific Understanding and Solves Real-World Problems

Christopher J. Fettig[1], Barbara J. Bentz[2], Nancy E. Gillette[3], Jane L. Hayes[3], Rick G. Kelsey[4], John E. Lundquist[5], Ann M. Lynch[6], Jose F. Negrón[7], Robert A. Progar[8], and Steven J. Seybold[1]

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Bark beetles cause extensive tree mortality in coniferous forests of western North America and play an important role in the disturbance ecology of these ecosystems. For many years, USDA Forest Service research scientists (www.fs.fed.us/research/) studied the biology, ecology and management of tree-killing bark beetles. Historically, research reflected an emphasis placed on protection of timber resources. Today, changes in societal values, global trading practices, and an increased awareness of the importance of disturbances in the functioning of forest ecosystems present previously unexplored questions. The Forest Service R&D Western Bark Beetle Research Group (WBBRG) was created in 2007 and includes scientists from the three western Forest Service R&D research stations with expertise in bark beetle research, development, and application in the West. To more fully address the current needs of land managers and the public, WBBRG met with forest health specialists from Forest Health Protection (www.fs.fed.us/foresthealth/) in 2007 to identify current research priorities that now guide much of our work (Negrón et al. 2008).

Negrón, J.F.; Bentz, B.J.; Fettig, C.J.; Gillette, N.E.; Hansen, E.A.; Hayes, J.L.; Kelsey, R.G.; Lundquist, J.E.; Lynch, A.M.; Progar, R.A.; and Seybold, S.J. 2008. USDA Forest Service bark beetle research in the western United States: Looking towards the future. Journal of Forestry 106: 325–331.

Distribution and Flight Periods of the California Fivespined Ips (*Ips paraconfusus*) in the Willamette Valley of Western Oregon

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This study represents the first systematic use of pheromone-based trapping to examine the distribution and flight periods of the California fivespined ips (*Ips paraconfusus*) in the Willamette Valley of western Oregon. Pheromone-baited funnel traps were placed at 11 sites along a latitudinal (North-South) gradient from 2008-2010. *I. paraconfusus* was the most abundant bark beetle over the range of the Willamette Valley ponderosa pine ecotype, consistent with anecdotal and historical observations. Other "tree-killing" bark beetles were collected in small numbers at a few sites and no new non-native bark or ambrosia beetles were detected. In the Willamette Valley, three peak flight periods and two generations of *I. paraconfusus* were observed. The abundance of *I. paraconfusus* was highly variable, and appeared to relate more to localized stand conditions than geography. Flight periods were generally similar by year and location, although southern and mid-Valley sites peaked earlier during the third flight. Recent trapping in the Columbia River Gorge National Scenic Area indicates that *I. paraconfusus* occurs further East in Oregon and Washington than was previously known. Study findings are helping to refine management strategies for new and existing plantings of Willamette Valley ponderosa pine as well as provide baseline data on bark beetle distributions in the Pacific Northwest.

Evaluating Aspen Damage and Decline in the Pacific Northwest

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This study focused on assessing the current stand conditions and primary damaging agents affecting aspen in the Pacific Northwest (PNW) by ground-based sampling of areas identified

in annual forest health aerial detection surveys (ADS). Forty-eight sites dominated by quaking aspen (*Populus tremuloides*) were evaluated in Oregon and Washington in 2010. Stand and site attributes, aspen regeneration, and the major damaging agents were recorded at representative plots. Preliminary observations indicate that 67% of stands were "stable", while 33% showed symptoms consistent with slow decline. Conifer competition was common and recorded in 63% of plots. Standing mortality of aspen stems (≥5 in dbh) ranged from 0 - 88% of total basal area, with the majority of stands having <33%. Aspen regeneration (<5 in dbh) was detected in 94% of plots, but only 42% of plots had advanced regeneration present. Ungulate damage, stem cankers, stem decays, and stem insects were the most common agents affecting live trees, while ungulate feeding, foliage diseases, and defoliating insects were most frequently observed impacting aspen regeneration. Additional surveys and assessments are planned at existing and new sites in 2011, and will assist in providing a broader assessment of aspen damage in the PNW as well as inform regional ADS coding.

Seasonal Effects of First Commercial Thinning on Ips Beetle Activity in North Mississippi Loblolly Pine Stands

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{No abstract submitted.}

Thermal Regulation of Niche Partitioning by Two Nutritional Symbionts of *Dendroctonus ponderosae*, *Grosmannia clavigera* and *Ophiostoma montium*

Melissa Friedman and Diana Six

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Dendroctonus ponderosae is a native eruptive herbivore in western North America and Canada. Warming climate has been correlated with beetle population growth, but the effect of temperature on the beetle's nutritional symbionts still requires exploration. D. ponderosae exists in a mutualism with two species of ophiostomoid fungi, Grosmannia Clavigera and Ophiostoma montium upon which it relies for nutritional benefits, while the fungi depend on the beetle for dispersal to a new host tree. Because these fungi have differing thermal tolerances and engage only in exploitative competition for phloem area, it is hypothesized that temperature regulated niche partitioning allows their coexistence. To explore the mechanisms of this relationship we will examine the growth rate, sporulation and competition of the two fungi under a range of temperatures.

Biology, Phenology, and Natural Enemies of Arkansas *Sirex*

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{No abstract submitted.}

Feeding a Mountain Pine Beetle Epidemic: The Role of Nutrition and Carbohydrates in Lodgepole Pine

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Ideally the fastest growing trees would be the most resistant to mountain pine beetle (MBP) attack. In an influential paper, Waring and Pitman (1985) argued that fertilization and thinning increased lodgepole pine resistance to MPB by increasing radial growth and carbohydrate reserves available for defense. However, our data indicate that fertilization diminished carbohydrate reserves in lodgepole pine trees. Therefore, fertilized trees may in fact have fewer carbohydrate reserves available to defend. Furthermore bolts cut from fertilized trees, and inoculated with four pairs of MPB, were more likely to produce living individuals in the spring than those cut from unfertilized trees. The positive effect of fertilization on MPB overwinter survival may be mediated by their fungal symbionts as these are more efficient at concentrating nitrogen in the phloem of fertilized trees than in the phloem of unfertilized trees. This was especially so for *Grosmannia clavigera* and *Leptographium longiclavatum*. Thus, available nutrients in the xylem, which are increased by fertilization, are likely more accessible to blue-stain fungi than are nutrients bound in plant tissues. As bark beetles consume phloem that is relatively low in nutrients, the concentration of nutrients in the phloem by their fungal symbionts may have important consequences for their survival and development that are amplified in fertilized trees. Because fertilization diminished lodgepole pine carbohydrate reserves, increased the amount of nitrogen concentrated by blue-stain fungi in the phloem, and had a beneficial impact on immature beetles, fertilization may be inadvisable during bark beetle outbreaks.

Waring, R; Pitman, G. 1985. Modifying lodgepole pine stands to change susceptibility to mountain pine-beetle attack. Ecology 66: 889-897

Thousand Cankers Disease on Black Walnut: Making the Jump to Tennessee

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In 2010, thousand cankers disease (TCD) was documented in Tennessee, representing the first confirmation of this disease in the native range of black walnut and the first known incidence of TCD east of Colorado. Tennessee Department of Agriculture personnel conducted surveys to determine the extent of TCD in counties in eastern Tennessee. Samples of symptomatic black walnuts were sent to the University of Tennessee for processing; the causative agents, walnut twig beetle, *Pityophthorus juglandis*, and the fungal pathogen *Geosmithia morbida*, were documented in four counties. Tree mortality was observed in two counties, and tree decline was observed in numerous counties (may be attributed to previous droughts or TCD). Four confirmed counties were quarantined by TDA in 2010, and 10 buffer counties also were regulated. Research is underway to further assess the incidence and impact of TCD on black walnut in Tennessee.

Interactions between an Old and a New Invader: How American Chestnut is Impacted by Two Exotics

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{No abstract submitted.}

Evaluating *Leucopis* Species (Diptera: Chamaemyiidae) from the Pacific Northwest as Potential Biological Control Agents of the Hemlock Woolly Adelgid

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Leucopis spp. (Diptera: Chamaemyiidae) from the Pacific Northwest were previously identified as potential biological control agents for the hemlock woolly adelgid, *Adelges tsugae* Annand (Hemiptera: Adelgidae), in the eastern United States. We collected *Leucopis* spp. larvae from *A. tsugae* infested western hemlocks in Oregon and Washington and reared them on an unidentified *Pineus* spp., *Pineus strobi* (Hartig), *Adelges cooleyi* (Gillette), *Adelges piceae* (Ratzeburg), and *A. tsugae* in three no-choice tests. *Leucopis* spp. survival was highest on *A. tsugae* in all three tests, but some larvae completed development on all four of the other adelgid species. Larvae that survived to the adult stage were identified as *Leucopis argenticollis* Zetterstedt and *Leucopis piniperda* Malloch. These results suggest that populations of *L. argenticollis* and *L. piniperda* in the Pacific Northwest may not be specific to *A. tsugae*. We also studied the phenology of *Leucopis* spp. on fourteen *A. tsugae* infested western hemlock trees in Oregon and Washington over a period of 14 months. *Leucopis* spp. larvae were collected year-round, but highest densities coincided with the presence of progrediens and sistens eggs and adults of *A. tsugae*. There was a positive correlation between *Leucopis* spp. and *A. tsugae* abundance.

Development of a Monitoring Program to Better Understand the Ecological Impacts of Wildfire under Warmer, Dryer Conditions on a Potentially Major Forest Defoliator

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Pandora moth, *Coloradia pandora davisi*, is a periodic defoliator of ponderosa pine in western pine forests of the United States. The last outbreak in Arizona began in 1979 on the North Kaibab Ranger District (NKRD) and crashed naturally in 1985 due to a nucleopolyhedrus virus that built up in the population. Pandora moth typically reaches outbreak levels in cycles of 20-30 years with outbreaks historically lasting 6-8 years with defoliation occurring in alternating years. Preliminary monitoring indicates that pandora moth is in the early stages of outbreak; 24,320 moths were captured in light traps during the summer of 2010 near Jakob Lake, AZ. This work spans three years and focuses on developing technologies that vastly improve pandora moth monitoring and provide a means to predict outbreak dynamics using remote sensing, sex at-

tractant pheromones, as well as field surveys of larvae and egg mass densities and defoliation. While pandora moth impacts have been relatively minor in the past, changing climate and stand conditions may influence the life cycle of the species thus altering the level of impact. Detailed information of the current outbreak will allow future research to isolate changes in pandora moth biology and the associated impacts.

Entomopathogenic Fungi for Control of Asian Longhorned Beetles

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{No abstract submitted.}

Effect of Trap Type, Trap Position, Time of Year and Beetle Density on Captures of the Redbay Ambrosia Beetle

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The exotic redbay ambrosia beetle (RAB), *Xyleborus glabratus* Eichhoff, and its fungal symbiont, *Raffaellea lauricola* Harrington, Fraedrich and Aghayeva, are responsible for widespread redbay (*Persea borbonia* (L.) Spreng.) mortality in the southern United States. Effective traps and lures are needed to monitor spread of the beetle and for early detection at ports of entry, so we conducted a series of experiments to find the best trap design, color, lure, and trap position for detection of RAB.

The best trap and lure combination was then tested at seven sites varying in beetle abundance and at one site throughout the year to see how season and beetle population affected performance. Manuka oil proved to be the most effective lure tested, particularly when considering cost and availability. Manuka oil release rates from 5-200 mg/d were equally effective and distributing multiple lures from the top to the bottom of 8-unit funnel traps resulted in similar numbers of RAB as a single lure in the middle. Trap color had little effect on captures. Funnel traps caught twice as many beetles as cross-vane traps and 3 times as many as sticky traps but mean catch per trap was not significantly different. Traps 1.5 m above the ground captured 85% of the beetles collected but a few were caught at each height up to 15 m. Funnel trap captures were strongly correlated (r^2=0.79) with RAB density and they performed well throughout the year even at very low densities.

Catching beetles at low densities is important to port of entry monitoring programs where early detection of infestations is essential. Our trials show that multiple funnel traps baited with a single manuka oil lure were effective for capturing *X. glabratus* even when no infested trees were visible in the area.

Hanula, J. L.; Sullivan, B. 2008. Manuka Oil and phoebe oil are attractive baits for redbay ambrosia beetle, *Xyleborus glabratus* (Coleoptera: Scolytinae), the vector of laurel wilt. Environ. Entomol. 37:1403-1409.

Hanula, J.L.; Ulyshen, M. D.; Horn, S. 2011. Effect of trap type, trap position, time of year, and beetle density on captures of the redbay ambrosia beetle (Coleoptera: Curculionidae: Scolytinae). J. Econ. Entomol. 104: 501-508.

Impact of Chinese Privet and its Removal on Pollinator Diversity and Abundance

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Chinese privet (*Ligustrum sinense* Lour.) was removed from riparian forests in the Piedmont of Georgia in November 2005 by mulching with a track-mounted mulching machine or by chainsaw felling. The remaining privet in the herbaceous layer was killed with herbicide in December 2006. Bee (Hymenoptera: Apoidea) abundance, diversity and community similarity in the forests was measured for two years after shrub removal and compared to heavily invaded controls and to non-invaded forests (desired future condition) using pan traps.

In 2006, control plots averaged 8.8 species and 34.8 bees/plot. Privet mulching resulted in 32.5 bee species and 418.3 bees/plot, and privet felling plots had 29 species and 259 bees/plot. In 2007 control plots averaged only 10 species/plot and 32.8 bees/plot, while mulched and felled plots had 48 and 38 species/plot and 658.2 and 382.5 bees/plot, respectively. The bee community on untreated control plots was dissimilar from the communities on privet felling, mulched and desired future condition plots during both years, however, by 2007, desired future condition, felling and mulched plots had similar bee communities.

Removal of an invasive shrub provided immediate benefits for native pollinators and resulted in bee communities similar to non-invaded forests even without further restoration of native plant communities.

Hanula, J.L.; Horn, S; Taylor, J. W. 2009. Chinese privet (*Ligustrum sinense*) removal and its effect on native plant communities of riparian forests. Invasive Plant Science and Management 2: 293-300.

Hanula, J.L.; Horn, S. 2011. Removing an exotic shrub from riparian forests increases butterfly abundance and diversity. Forest Ecology and Management 262: 674-680.

Hanula, J.L.; Horn, S. *In press*. Effects of an invasive shrub (Chinese privet) and its removal on bee communities in riparian forests. Insect Conservation and Diversity.

Influence of Climate and Weather on Observed Spatiotemporal Patterns of Mountain Pine Beetle Outbreaks in Washington and Oregon

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{No abstract submitted.}

Effects of Bark Beetle-Caused Tree Mortality on Subsequent Wildfire

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{No abstract submitted.}

Detection and Field Identification of the Goldspotted Oak Borer, *Agrilus auroguttatus* (Coleoptera: Buprestidae)

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The goldspotted oak borer (GSOB), *Agrilus auroguttatus*, is an invasive buprestid beetle that as of 2010 has caused the death of approximately 21,500 oaks over 1,893 square miles in San Diego Co., CA (Hishinuma et al., 2011). In order to aid in proper identification and assessment of GSOB infestation we have developed a field identification guide. The guide covers external and internal symptoms of GSOB infestation, host tree species, management options, and a tree health rating system for evaluating the severity of GSOB infestation. The field guide was published online through the University of California Statewide Integrated Pest Management Program with the support of the USDA Forest Service.

Hishinuma, S.; Coleman, T. W.; Flint, M. L.; and Seybold, S. J. 2011. Goldspotted oak borer: Field identification guide. University of California Agriculture and Natural Resources, Statewide Integrated Pest Management Program, 6 pp., January 13, 2011, http://www.ipm.ucdavis.edu/PDF/MISC/GSOB_field-identification-guide.pdf.

Controlling Bark Beetles with Acoustics

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Because of the significant impacts bark beetles have on forests, scientists and forest managers have sought a variety of solutions to bark beetle outbreaks. We explored the use of acoustics in mediating bark beetle activity and reproduction within wood tissues. Biologically relevant sounds induced stress that reduced the decision-making capacities, reproduction, and survival of beetles. Our findings suggest that acoustic signals can disrupt insect behaviors, thus reducing the ability of insects to reproduce and further damage plant materials. The use of acoustics could be a species specific and environmentally friendly method of pest management.

Has the "Vine that Ate the South" Finally Met its Match? Biology and Biocontrol Potential of the Accidentally Introduced Kudzu Bug (*Megacopta cribraria*)

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Kudzu was introduced into the United States from Asia in 1876 and promoted as both a forage crop and ornamental. However, by the 1950's it was listed as a weed and now covers over 2,000,000 acres in the South and causes considerable ecological and economical damage. Initial efforts to find a suitable biocontrol agent were unsuccessful because all insects that fed on kudzu fed on other Fabaceae as well therefore importation was not an option. However, in

October 2009 *Megacopta cribraria* was found in a few Georgia counties and has since rapidly its range. This was the first time the family Plastaspidae has been found in the New World. In Asia, it predominantly feeds on legumes such as soybean and kudzu. We set out to determine basic biological parameters of this new introduction, as well as whether or not it could be a biological control agent of kudzu. We found that in our area M. cribraria goes through five instars to complete development and has 2 generations per year. To determine the impact on kudzu, we used biweekly insecticide treatments (Cyonara) during the growing season to protect some plots while allowing M. cribraria to readily feed on control plots. Our results showed that kudzu bug feeding caused a significant reduction in kudzu biomass over the course of one growing season. Stem, leaf, and stem and leaf biomass combined each had over 32% reductions compared to sprayed plots where bugs were excluded.

The Northernmost Emerald Ash Borer Population in Upper Michigan: Delimitation and Reconstruction

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Emerald ash borer (*Agrilus planipennis* Fairmaire, or EAB) is an exotic pest of ash (*Fraxinus* spp.) native to Asia. Since its discovery in North America in 2002 it has been found in fourteen U.S. states and two Canadian provinces and has infested or killed more than 50 million trees in Michigan, Ohio and Indiana alone. An outlier population of EAB was confirmed in Houghton County, Michigan in August 2008. This is the northernmost find of EAB in North America and when it was found was more than 250 miles from the closest known population. Over one hundred and ninety ash trees have been destructively sampled to help determine how EAB has spread in Houghton County. Preliminary dendrochronological analysis indicates EAB became established in Houghton County in 2003. Traditional EAB delimitation surveys are costly and time consuming. A ground survey using a novel technique was initiated during summer 2009 to determine the extent of the ash resource and visual signs and symptoms of EAB around the Houghton County infestation. Transects were run in the four cardinal and four intercardinal directions for 3.2 kilometers radiating outward from a known infested tree. Basal area by species was assessed along each transect. Any ash tree found was assessed for health and signs and symptoms of EAB. Ground survey located two additional infestations 0.8 kilometers south and 1.2 kilometers southwest of the original EAB find. Another population was located by an earlier ground survey in October of 2008 0.8 kilometers west of the initial find. Transects were run from each of these additional populations, but no new infestations were located. This site continues to be evaluated to further characterize the extent of ash resources and EAB infestation. The radiating transect sampling methodology is undergoing further assessment and refinement.

Operation Adelgification: Evaluating a Rain Down Technique to Artificially Infest Seedlings with the Hemlock Woolly Adelgid

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Over the last two decades, the hemlock woolly adelgid (HWA, *Adelges tsugae* Annand) has caused widespread mortality among populations of Eastern (*Tsuga canadensis* (L.) Carriére) and Carolina (*Tsuga caroliniana* Engelmann) hemlock throughout the eastern United States. The integrated strategy to manage the impacts of this invasive insect pest on eastern forests includes biological control, chemical insecticides, silvicultural practices, and gene conservation (Onken and Keena 2008). During the last nine years considerable progress has also been made in understanding hemlock-adelgid host-insect interactions and the potential for breeding hemlocks resistant to HWA. Operational programs for selecting and breeding hemlock genotypes that express resistance characteristics will require infesting large numbers of hemlock seedlings with HWA, and techniques for doing this in a consistent and reliable manner are currently lacking. Our poster presents the results of a pilot study designed to test an adelgid crawler (1st instar nymphs) rain down technique for inducing mass seedling infestations. We evaluated the distribution and abundance patterns of HWA progrediens crawlers allowed to rain down on 1m^2 glue sheets inside 1m^3 PVC cages. After evenly covering a 1m^2 wire frame on top of each PVC cage with HWA-infested branches, we found that progrediens crawlers "rained down" and were well distributed over the surface below. Occasional "hot spots" of highly-concentrated crawlers on the glue sheet presumably resulted from corresponding dense clusters of ovisacs above. The "high" ovisac treatment (48 branches) resulted in significantly more crawlers raining down than the "low" ovisac treatment (24 branches), on average 205.58 (±17.93) and 115.97 (±13.02) crawlers per 20cm^2, respectively. Extrapolating from mean counts made on 2x2 cm squares, an estimated 290,000 and 514,000 crawlers per m^2 fell beneath the low and high ovisac treatments, respectively. This rain down technique shows promise for applying ample infestation pressure on large numbers of seedlings simultaneously in resistance screening trials. Current and future work will compare infestation success on seedlings subject to the rain down technique versus other methods of adelgification.

Onken, B. and M. Keena. 2008. Hemlock wooly adelgid initiative: progress and future direction. pp. 214-220 In: B. Onken and R. Reardon (Eds.), Proceedings of the Fourth Symposium on Hemlock Woolly Adelgid in the Eastern United States. FHTET-2008-01,USDA Forest Service, Morgantown, WV.

Forest Health Evaluation Tool

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Many small forest land owners (SFLOs) in NE Washington manage their stands to achieve resistance and resiliency to key pests. However, they often lack stand level information on which to base management decisions related to forest health and implement silvicultural treatments. The objectives of this project are to develop a tool for use by SFLOs, or their consultants, and stewardship foresters to describe the current status of client's stands related to forest health, prioritize stands for silvicultural treatments, and evaluate change in stand conditions related to silvicultural treatment. Data are collected on plots installed systematically through the stand. Variable radius plots are used in commercial size stands. Fixed radius plots are used in pre-commercial size stands. Data are recorded into a spreadsheet in a prearranged format. The spreadsheet is pasted into a workbook and referenced by numerous spreadsheets that calculate descriptive statistics, forest health indices, and hazard/risk ratings. The workbook generates the current status report and additional output used by associated workbooks to prioritize and evaluate silvicultural treatments. The current status summary provides descriptive statistics,

stand level indices related to forest health, current damage from selected key pests, and hazard/risk ratings. The background color of selected cells (green, yellow, orange, or red) is related to and changes with risk thresholds. The stand summary is followed by more detailed information listed by host species, DBH class, and/or key pest. Tabular information is followed by a series of graphs. Output is arranged in a single record for each stand and entered into a second spreadsheet. Stands are sorted and filtered by indices according to criteria associated with various cost share grants to help stewardship foresters prioritize silvicultural treatments. Outputs obtained for a stand prior to and following treatment are entered into a third spreadsheet to compute change in forest health indices, current levels of damage, and levels of hazard/risk to key pests.

Assessing the Establishment of Predator Beetles Released to Control Hemlock Woolly Adelgid in the North Georgia Mountains

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In efforts to control Hemlock woolly adelgid, *Adelges tsugae* (Hemiptera: Adelgidae) (HWA) in the Chattahoochee National Forest (CNF) of northern Georgia, 3 biological control beetle labs were established in GA (YH, UGA, and NGCSU), as well as receiving additional support from CU in SC. Over 100 Hemlock Conservation Areas (HCAs) were established in the CNF where, since 2006, close to 1 million predator beetles, (*Sasajiscymnus tsugae* (St): (Coleoptera: Coccinellidae), *Laricobius nigrinus* (Ln): (Coleoptera: Derodontidae), and *Scymnus sinuanodulus* (Ss): (Coleoptera: Coccinellidae)) were released. In order to determine the establishment of predatory beetles through recovery efforts, HCAs were sampled in 2009 (n=4), 2010 (n=13), and 2011 (n=14) by collecting foliage prior to any adult releases for the season. The twigs were taken back to the lab, put in a floral foam blocks, and placed in rearing cages (one for each HCA). Additional HWA infested twigs, from non-release areas, were added weekly along with watering the foam block. Emerging beetles were collected and recorded with preliminary results showing recovery in 2009 (2 HCAs), 2010 (10 HCAs), and 2011 (9 HCAs). All samples were stored in 95% EtOH in a freezer until DNA analysis is conducted by USDA FS, Northern Research Station at Yale University. The identification of these samples will provide insight as to which beetle species are being recovered and are possibly establishing in North Georgia. It will also tell us whether Ln and Lr are hybridizing in the field.

Using Asian Longhorned Beetle Semio-Chemicals and Host Plant Volatiles to Monitor for its Presence

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An operationally effective trap to monitor the Asian longhorned beetle (*Anoplophora glabripennis* or ALB) has been a goal of the US ALB eradication program since the first beetle was found in New York in 1996. Ground surveying is only ~20% accurtate at identifying infested trees and al-

though tree climbing is more accurate, it is also highly time consuming and expensive. In order to develop a trap and lure combination that is effective, we documented and developed a better understanding of ALB reproductive behaviors and mating requirements to maintain female fertility. We evaluated various combinations of the ALB male produced pheromones and plant volatiles in a quarantine greenhouse and in China. We also tested a few different trap designs. In 2009 in Worcester, MA, Intercept® panel traps were placed on or near maple trees, within the lower part of the tree canopy, and checked at least twice a month, June-Nov. Six different lure treatments and an unbaited control were replicated 14 times for a total of 84 traps. A total of 9 adult ALB, all females, were caught in the traps. The highest number of beetles was caught in the same combination of male pheromone and 5 plant volatiles that was found most effective in China. Two particularly important locations where beetles were caught were where 2 beetles were caught in an area thought to have been cleared of all infested trees, and another where host trees were scarce and scattered. Guided by these trap catches, new infested trees were found. In June 2010, we deployed the best lure and trap combination in Worchester, MA (total of 40 traps) to assist in pinpointing lingering populations of ALB. We again caught female ALB (4 total) in areas that were thought to be free of infested trees and this lead to additional finds of infested trees. From data obtained from APHIS about where the infested trees had been found, we were able to estimate that the traps can draw beetles in from at least 80 meters. In 2011, we will expand the trapping work in Worcester. MA and conduct some research to further refine the lures.

Ethanol Concentrations in Sapwood of Coast Live Oak With and Without *Phytophthora ramorum* Cankers

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Ethanol concentrations were quantified in *Quercus agrifolia* sapwood along a transect inside and outside of *Phytophthora ramorum* cankers on diseased trees and at comparable locations on paired healthy trees. Two types of cankers were tested; small spot cankers surrounded by healthy tissues and larger cankers at the stem base extending all the way to the forest floor. The sapwood ethanol concentrations depended on the canker type and the position relative to the canker boundary. The median ethanol concentration from inside the cankers was 15.5 times greater than in healthy tissues 15 to 30 cm outside the canker border. Sapwood removed from large basal cankers contained 4.3 times more ethanol than sapwood from inside spot cankers. Ethanol concentrations were extremely variable from different sample points within the same canker, or from the same location within cankers from different trees. Sapwood from paired healthy check trees had low ethanol concentrations at all sample points. The release of ethanol from sapwood to the atmosphere was demonstrated by adding an ethanol solution to sealed holes in an Oregon white oak (*Q. garryana*) bolt, as a surrogate for *Q. agrifolia*. Ethanol was first detected in charcoal traps on the bark surface three days after its addition to the holes, with the highest release rates from fissures where the bark was thinnest. Bark and ambrosia beetles focus their attacks inside the boundaries of *P. ramorum* cankers on coast live oak where ethanol concentrations are highest. Since ethanol is a known attractant for some of these beetle species, it is likely a major contributor to their preference for colonization of the *P. ramorum* cankers.

Abundance And Taxonomic Richness Of Leaf Mining Insects On Alien Woody Plant Species In Siberia

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In Siberian botanical gardens, we examined 45 alien woody plant species from 13 genera: *Betula, Caragana, Crataegus, Lonicera, Malus, Populus, Prunus, Rosa, Salix, Spiraea, Tilia, Ulmus, Viburnum,* originating from Europe, North America and East Asia, and closely-related native congeners: (I) to estimate abundance and taxonomic diversity of native leaf miners on alien and native plants; (II) to check if the origin of alien plants (Europe, North America, East Asia) plays a role in their colonization by leaf miners; (III) to assess if trophic specialization of leaf miners (i.e. mono-, oligo- and polyphagy) influences the adoption of new hosts.

(I) The level of attack by leaf miners and their diversity in general were significantly lower on alien plants than on their Siberian relatives. 68 leaf miner species were recorded on alien plants. The abundant insects were from the genera *Phyllonorycter, Stigmella* (both Lepidoptera) and *Aulagromyza* (Diptera). Alien birches were attacked by the richest (14 species) taxonomic complex of leaf miners.

(II) Alien plants from distant regions (Europe and North America) were less damaged by leaf miners than closely-related native plants, whereas no significant difference in insect attack was found for plants originating from neighbouring regions: East Asia (alien plants) and North Asia (native plants).

(III) Mono- and oligophagous leaf miners, i.e. trophically more specialized groups, attacked alien plants much less than Siberian congeners. No significant difference was found for polyphagous leaf miners.

The study was supported by the grant of President of the Russian Federation (grant No. MK-7049.2010.4), Russian foundation for basic research (grant No. 10-04-00196-a), the grant of Academician Lavrentiev, Siberian branch of the Russian Academy of Sciences (grant No. 19) and EU project PRATIQUE (FP7).

Three Years of Bark and Wood Boring Beetle Activity Following Pacific Coast Windstorm

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Severe windstorms along the coast of Washington over three days in December 2007 resulted in substantial amounts of windthrown trees in some areas. Monitoring for bark and wood boring beetle activity at three windthrow sites on state lands began spring 2008. The objective of this study was to monitor changes in the bark and wood boring beetle community in un-salvaged areas for three years following storm damage. Beetle flights were monitored using ethanol and alpha-pinene baited funnel traps with and un-baited passive flight intercept traps. 13,019 specimens of bark and ambrosia beetles representing 24 species in 16 genera were collected over three years. *Gnathotrichus* spp. ambrosia beetles (*Gnathotrichus retusus* and *G. sulcatus*) were by

far the most abundant beetles collected. *Gnathotrichus* spp., *Xyleborinus saxeseni*, *Hylastes nigrinus*, alder bark beetle (*Alniphagus aspericollis*), and *Anisandrus dispar* flights were largest in the third year. Ten times more alder bark beetles, *A. aspericollis*, were collected in passive flight intercept traps (102) than in baited funnel traps (10). Douglas-fir beetle (DFB), *Dendroctonus pseudotsugae*, adult collections increased in the second spring after the storm, and remained high for two years. DFB attacks of standing live trees were observed in 2009 at two sites. For two years, bolts cut from windthrown trees were placed in emergence traps. No Douglas-fir beetles were collected from emergence traps until 2009. Very few silver fir beetles (SFB), *Pseudohylesinus sericeus*, were collected in the field in 2008. However, 317 SFB adults emerged from Pacific silver fir bolts in 2008. These were likely reemerging for second attacks. Two SFB adults also emerged from western hemlock bolts. *Gnathotrichus* spp. and *Trypodendron lineatum* adults emerged from both western hemlock and Douglas-fir in 2008 and 2009. Most bark and ambrosia beetles increased populations in windthrown trees, resulting in higher adult flights in the second and/or third years following the storm. Most wood damage and introduction of decay fungi likely occurred during the first two years while broods were increasing.

Interactions between the Fungal Biopesticide, *Lecanicillium muscarium*, and the Biological Control Agents used for Hemlock Woolly Adelgid, *Laricobius nigrinus and Sasajiscymnus tsugae*

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A new tactic to manage hemlock woolly adelgid (HWA) using the entomopathogenic fungus, *Lecanicillium muscarium*, is currently being tested in the field. The two most common predators used in the biological control program for HWA, *Laricobius nigrinus* and *Sasajiscymnus tsugae*, were sprayed with *L. muscarium* to determine any direct effects the fungus may have on the predators. *L. nigrinus* eggs and young larvae treated with fungus suffered a higher mortality rate than the control; there was no effect on older larvae. *S. tsugae* eggs were not affected by the treatment, but 3rd instar larvae had very low success developing to adults when treated with fungus compared to controls. The mortality of HWA was very high in the dishes treated with *L. muscarium*. *L. nigrinus* develops and leaves the tree before *L. muscarium* treatments would begin, however further work would be required to determine the impact of *L. muscarium* on pupating *S. tsugae* under natural conditions.

Operational Aerial Application of MCH Flakes on Bald Mountain Ski Area, Ketchum Ranger District, Idaho

Laura Lazarus

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Populations of Douglas-fir beetle (DFB) began to build in 2009 on Bald Mountain Ski Area (BMSA) in response to the 2007 Castle Rock fire. A treatment strategy including an aerial application of the anti-aggregant MCH was planned for 2010 to (1) protect stands of susceptible Douglas-fir (DF) on the BMSA from undesirable attack and mortality caused by DFB, and (2) to implement the proposed aerial application of MCH flakes in a safe, effective, and efficient man-

ner. DFB attacked 0.5 mean basal area (BA) ft^2/acre, or 0.7 trees per acre (TPA), in treated areas and 21 mean BA ft^2/acre, or 14.7 TPA, in untreated areas. MCH flakes successfully reduced DF mortality when the proper dosage was applied. Lessons learned include influences of treatment block size and wind on flake distribution. Treatment in 2011 is recommended because DFB populations are still high in the area and BMSA is highly susceptible to attack. The suggested treatment for 2011 is one well-timed aerial application of MCH flakes over about 1,500 acres in 2011 in combination with deployment of MCH pouches on approximately 125 acres.

IUFRO as a Resource for Forest Insect and Disease Research

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{No abstract submitted.}

Managing Emerald Ash Borer in Pennsylvania: A Community Approach

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The emerald ash borer (EAB), *Agrilus planipennis* Fairmaire (Coleoptera: Buprestidae), an exotic woodborer from northeast Asia, was first discovered attacking ash trees in Michigan in 2002. Since then, it has been found in 15 U. S. states and two Canadian provinces. An estimated 20 to 55 million ash trees have been killed by this pest in the infested areas. Managing this pest has been confounded by difficulties in early detection, limitations in control options, and scarcity in available resources. Tree removal works for small outlier infestations, whereas chemical control is effective on high-value ash trees. However, long-term management will ultimately depend on biological control. We initiated an integrated pest management (IPM) project by utilizing mechanical, chemical and biological control measures in a selected community in 2010 to serve as a model for EAB management in Pennsylvania. A tree inventory was conducted at the beginning of this project to document ash resource and its conditions. Each ash tree was geo-referenced and evaluated for EAB infestation. Management measures were then assigned to different plots to meet the management goals of the landowner. Heavily infested trees along major roads and trails were removed to reduce EAB source populations and potential safety hazards. High value ash trees will be protected with Treeage (emamectin benzoate) through trunk injection in the summer of 2011. At the same time, three hymenopteran parasitoids will be introduced into one of the plots throughout 2011for permanent establishment and long term suppression of EAB within the study site, including larval parasitoids *Tetrastichus planipennisi* Yang (Eulophidae) and *Spathius agrili* Yang (Braconidae), and egg parasitoid *Oobius agrili* (Encyrtidae). A total of 598 ash trees were inventoried from 13 plots in the study sites, with an average DBH (diameter at breast height) of 30.2 cm, ranging from 10.4 to 94.0 cm. Of those examined trees, 47.3% showed some signs of EAB infestation, with an average crown rating of 43.4%. A total of 17 infested trees were removed, with an average density of 35.1, ranging from 6.5 to 140.6 larvae/m^2. Chemical and biological control activities are still ongoing, with efficacy and impact evaluations scheduled for the summer of 2012. Training of local communities on EAB management has also started.

Changing Distribution of Amber-Marked Birch Leaf Miner (*Profenusa thomsoni*) Across the Anchorage Urban Landscape

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{No abstract submitted.}

Redbay Ambrosia Beetle Attraction To and Emergence from Bolts of Various Lauraceous and Non-lauraceous Trees

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The redbay ambrosia beetle (RAB, *Xyleborus glabratus* Eichhoff) is a non-native invasive insect of Asian origin that was first detected in the U.S. in 2002. It carries a fungal symbiont (*Raffaelea lauricola*) that causes a vascular disease known as laurel wilt in certain members of the plant family Lauraceae (Fraedrich et al. 2008). In this study, we examined the attractiveness of bolts of various tree species to the RAB and subsequent beetle emergence from that material. In 2010 we also monitored an additional non-native ambrosia beetle, *Xylosandrus crassiusculus* (Motschulsky), and the effect of treating bolts with a wax end sealant prior to field deployment. In 2009, camphortree (*Cinnamomum camphora,* Lauraceae) was as attractive to RAB as swampbay (*Persea palustris,* Lauraceae). Sweetbay (*Magnolia virginiana,* Magnoliaceae) was as attractive as avocado (*Persea americana,*Lauraceae) and lancewood (*Ocotea coriacea,* Lauraceae). Loblolly bay (*Gordonia lasianthus,* Theaceae), which commonly co-occurs with swampbay, was not more attractive than an unbaited control. RAB entrance hole density was highest on camphortree and swampbay. In 2010, sassafras (*Sassafras albidum,* Lauraceae) was less attractive to RAB than swampbay, but more attractive than the unbaited control. Flightless males emerged from swampbay and sassafras, confirming brood production. RAB emerged from swampbay bolts for more than 5 months post collection, whereas *X. crassiusculus* emerged for only 2.5 months post collection. Application of end seal decreased the number of RAB entrance holes on swampbay, and decreased trap catch, entrance hole density, and emergence of *X. crassiusculus.* For the purpose of attracting and rearing these two ambrosia beetle species, end-sealing bolts with a wax-water emulsion prior to field deployment is not recommended.

Fraedrich, S.W.; Harrington, T.C.; Rabaglia, R.J.; Ulyshen, M.D.; Mayfield A.E. III; Hanula, J.L; Eickwort, J.M.; and Miller, D.R. 2008. A fungal symbiont of the redbay ambrosia beetle causes a lethal wilt in redbay and other Lauraceae in the southeastern USA. Plant Disease 92:215-224.

Estimating Herbivorous Insect Diversity on the Native *Ilex vomitoria* and the Invasive *Ligustrum sinense* in Southern Louisiana

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Invasive species cause major economic and ecological losses worldwide. The estimated yearly cost of invasive alien species in the United States is $120 billion. One species that was intentionally introduced as an ornamental into the southern U.S. and has become problematic is *Ligustrum sinense* Lour. (Chinese privet). One hypothesis why some non-native species are more abundant and widely distributed in their introduced than native range is the Enemy Release Hypothesis (ERH). This hypothesis posits that reduced herbivores and natural enemies may contribute to the increased distribution and abundance of the non-native in its introduced range (Elton 1958, Keane and Crawley 2002). This study compared the insect communities of the invasive *L. sinense* and native shrub *Ilex vomitoria* in Louisiana. *I. vomitoria* was selected for comparison as it occupies a similar niche to *L. sinense* in southern Louisiana. If ERH is a contributing factor to the invasiveness of *L. sinense*, we would predict that *L. sinense* would support a lower herbivore population than the native, *I. vomitoria* in Louisiana. Our results displayed a similarity in the number of families collected on *I. vomitoria* & *L. sinense*, similar distributions of functional feeding groups but differences in the composition of how these families are distributed among functional groups. From these results there is not strong evidence for supporting ERH as an obvious mechanism for the invasion of *L. sinense*.

Coast Live Oaks Exhibit Quantitative Resistance to *Phytophthora ramorum*

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{No abstract submitted.}

Ineffectiveness of the *Sirex* UHR Lure to Attract Native *Sirex* in Louisiana

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Numerous attempts to trap native *Sirex* species (i.e., *Sirex edwardsii* and *S. nigricornis*) during the annual fall flight from 2005 through 2009, utilizing a variety of sites, traps, lures and combinations of such, most notably the *Sirex* UHR lure (70% alpha-pinene [75% plus enantiomer]/30% beta-pinene; Synergy Semiochemicals, Corp., Burnaby, BC, Canada) have all appeared to be woefully ineffective compared to observed *Sirex* activity on freshly felled pine material (i.e., bucked and stacked bole material next to green-needled tops). To test the relative attractiveness of a fresh pine lure, 30 panel traps (Alpha Scents, Inc., Portland, OR) were deployed in a linear array ca. 100 ft. apart from each other on Oct. 20, 2010, in a recently thinned sawtimber-sized pine stand on the Kisatchie National Forest (Grant Parish, LA). Three trap treatments were then assigned among 10 replicate trap groups. Trap treatments consisted of: 1) The national *Sirex noctilio* survey lure (above); 2) A nylon mesh (Amber Lumite® screen, 32 x 32 mesh/in.) "pine bag" (10" x 36"), containing 10-12 freshly split loblolly pine billets (12" long) and 10-12 pine boughs with green foliage (total weight ca. 10 lbs); and 3) an unbaited control. Lures were replaced on Oct.

27 and Nov. 23, and trapping terminated on Dec. 27. The 30 traps on this single site yielded 306 female *Sirex* spp. (203 - pine bag; 68 - *Sirex* UHR; 35 - untreated blanks). Mean trap catch for the fresh pine bag lure was an order of magnitude greater than that for the *Sirex* UHR lure and blank traps (i.e., 11.3 *Sirex* spp. vs. 1.8 vs. 0.6, respectively). The initial Friedman Test indicated a significant difference among lures ($x^2 = 16.36$, $p > x^2 = 0.0002$). Pairwise comparisons indicated the pine bag treatment was significantly more attractive than both the *Sirex* UHR and blank treatments at a critical level of $\alpha=0.01$. Interestingly, the *Sirex* UHR lure did not differ from the blank ($\alpha=0.01$).

Revision of the New World *Hylurgops* LeConte (Curculionidae: Scolytinae)

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The New World species in the genus *Hylurgops* LeConte are revised. A new key to the subtribe Hylastina improves the diagnosis between the genus *Hylurgops* and *Hylastes*. *Hylurgops subcostulatus* Mannerheim is removed from the genus. The Nearctic *H. knausi* Swaine is resurrected, and is separated from *H. planirostris* Chapuis of the high montane Neotropical region. The subspecies *H. rugipennis pinifex* Fitch as treated by Wood (1982) is considered a valid species. A revised key to the *Hylurgops* species of the New World is presented.

Attaching Lures to Funnel Traps for Saproxylic Beetles: Inside or Outside Funnels?

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Our objective was to determine the effect of hanging lures within multiple-funnel traps compared to hanging them outside the funnels. Two trapping experiments were conducted in stands of mature pine in Georgia USA, each with the following treatments: (1) lures within the funnels; and (2) lures outside the funnels. In each experiment, we used 20 multiple-funnel traps, grouped into ten replicate blocks of two traps per block. We used 8-unit multiple-funnel traps in Expt. 2 whereas we used 10-unit multiple-funnel traps in Expt. 1. Traps were hung between trees by rope and spaced 8-12 m apart. Each collection cup contained about 250 ml of RV & Marine antifreeze.

All traps in Expt. 1 were baited with ipsenol and ipsdienol bubblecap lures, and ethanol and (-)-α-pinene ultra-high release rate (UHR) pouches whereas all traps in Expt. 2 were baited with ipsenol and ipsdienol bubblecap lures, and a low-release rate (-)-α-pinene bottle lure (15 mL). In Expt. 1, traps with treatment 1 were modified in order to place the UHR lures within the funnels. The diameter of the center hole of each funnel with a treatment 1 was increased from to 5.5 to 12.0 cm. The trapping periods for Expts. 1 & 2 were 24 July - 29 August and 29 August - 7 October 2008, respectively.

We found that bark and wood boring beetles (and their associates) were either unaffected by the location of lures on funnel traps, or preferred traps with lures placed within the funnels. Hanging lures on the outside of traps did not result in increased catches of any species or species group that we monitored.

Comparing Traps for Wood Boring Beetles in Southeast USA: Lindgren Multiple-Funnel vs Intercept Panel vs Colossus Pipe

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Our objective was to compare the efficacy of three commonly-used traps for catching bark and wood boring beetles in North America. In 2004, we evaluated 8-unit Lindgren multiple-funnel, Intercept panel and Colossus pipe traps, baited with ethanol and α-pinene in pine stands in Florida (30 Mar – 16 Jun) and South Carolina (14 Apr – 29 Jun). Thirty traps were grouped into ten replicate blocks of three traps per block with one of each trap type in each block. Traps were hung between trees by rope and spaced 8-12 m apart; blocks spaced 10-20 m apart. Each collection cup contained about 250 ml of RV & Marine antifreeze.

We found that Intercept panel traps are as good as, if not better than, multiple-funnel and Colossus pipe traps for catching wood borers. However, variation among trap performance for associated species suggests that detection programs should consider more than one type of trap in their protocols.

The Significance of Alert Citizens in Twenty Years of Exotic Pest Detection in Washington State

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This poster summarizes exotic pest introductions tracked by the Washington State Department of Agriculture over the past 20 years, categorizing detections into three groups – targeted survey detections, non-target discoveries, and submissions from private citizens. Over 50 introduced pests have been detected during this time; this figure does not include some regularly detected and eradicated pests (e.g. European gypsy moth). Thirty-six percent of new records originated from alert citizens, including homeowners, nursery workers, and off-duty biologists. Twenty-nine percent of new records were from non-target captures during targeted surveys; the remaining new pest detections were survey targets. Citizen contributions to early detection of exotic pests are significant, equaling the total captured in targeted surveys. This source of exotic pest detection should be valued and supported.

Differential Responses of Hemlock Woolly Adelgid and its Predators on Hemlocks across a Spectrum of Resistance: a Research Plan

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{No abstract submitted.}

Ground-Dwelling Spider Community Recovery Five- and Eleven years Post-Harvest in Boreal Mixedwood Forests

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Clear-cut logging is extensively used to harvest boreal forest across Canada and its immediate effect on the biota has been well relatively documented (e.g. loss of forest specialists and colonization of early successional species). However, the point at which clear-cut stands begin to recover is unknown. To investigate this, epigaeic spiders were studied in three regenerating spruce stands and three of aspen at five- and 11 years post-harvest. Three mature control stands of each of these stand types were also examined to give a reference to unharvested conditions. Spiders were collected using pitfall traps over a 12 week period during the summer of 2010 in Northern Alberta. Results showed that five year post clear-cut spider assemblages were similar irrespective of pre-harvest forest type, whereas the 11 year post clear-cuts differed: the deciduous stands began to converge with control stands of that type, whereas the conifers remained distinct. Overall, species richness was generally greater in the second sampling year and did appear to be related to treatment (clear-cut or control). Common species of mature deciduous forests were found frequently in both five and 11 years regenerating stands whereas several species common in mature conifer forests had not colonized at five or 11 years post clear-cut. Findings suggest that pre-harvest forest type influences spider fauna recovery after clear-cutting. Deciduous stands respond more quickly, probably because conditions in 11 year regenerating stands are more similar to the mature state. Unique species supported in conifer stands do not colonize as quickly suggesting it will take longer for these forests to recover.

Forest Tent Caterpillar Egg Hatch is Independent of Bud Break Phenology Despite Significant Fitness Costs Imposed by Asynchrony

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Forest tent caterpillar, *Malacosoma disstria* Hubner (Lepidoptera: Lasiocampidae) (hereafter FTC) hatches in synchrony with bud break of its primary host plants. Quaking aspen (*Populus tremuloides*), a dominant host species across the northern range of FTC, grows clonally and exhibits large variation in the timing of bud break among genets presenting a significant challenge to early spring-feeding insects. The relationship between bud break timing and FTC hatch was assessed by forcing gravid females to oviposit *in situ* on five trees each of a late and early flushing clone. The timing of hatch was quantified for all egg masses in relationship to development of buds and shoots. Development of caterpillars through to pupation was recorded on each clone for naturally emerging larvae and for an additional larval cohort whose hatch was adjusted for synchrony with bud break in each clone. The timing of egg hatch was not altered by tree phenology: eggs hatched at the same time on early and late flushing aspen clones. Lack of synchrony with the late flushing clone significantly reduced pupal mass, a correlate of fecundity, and increased the development time of larvae. In contrast, no difference was found between early and late clones when hatch timing was adjusted for synchrony with bud break.

Environmental Factors & Population Dynamics Affect the Efficacy of TM Biocontrol-1 on Douglas Fir Tussock Moth

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The Douglas-fir tussock moth (*Orgyia pseudotsugata*) is an important pest of northwestern forests and, during outbreak cycles defoliates its main host tree, Douglas-fir (*Pseudotsuga menziesii*). Insect outbreaks are usually terminated by natural or artificially initiated epizootics of a nucleopolyhedrovirus. We examined the dynamics of epizootics in (N = 3, each) sprayed (pesticide TM Biocontrol-1) and control plots during a tussock moth management program in N. Central Washington State (USA) with field observations of disease spread, followed by fitting of stochastic models of disease transmission. Models indicated that, although an epizootic was started earlier in sprayed populations, initial infection rates in control populations may have been high enough to prevent defoliation through high transmission late in the season. Peak infection rates were ~0.65 in the sprayed plots and ~0.35 in the control plots after the first 20-30 days post-spray. Continued transmission caused the late-season epizootic in the control plots resulting in a second increase in infection rates after 30-40 days to ~ 0.85. In a greenhouse experiment, we tested an additional hypothesis that the efficacy of TM Biocontrol-1 varies with temperature. Baculoviruses such as NPV have been shown to decay with temperature and exposure to UV radiation in other study systems; thus temperature has the potential to affect the efficacy of pesticide spray programs. Populations of tussock moth larvae were maintained on Douglas-fir seedlings at two temperatures (mean temperature difference ~2.5 ºC) with no virus or treated with virus allowed to decay for 0, 1, or 3 days. In the greenhouse experiment warmer temperatures increased the speed of kill by TM Biocontrol-1 by an average of ~1.5 days relative to cooler temperatures. There was, however, no significant effect of virus decay time on speed of kill although a trend toward decreasing efficacy with increasing decay time was evident, indicating the need for field experiments given that greenhouses attenuate UV radiation. Therefore, the geographic extent of the spray program may have led to differences in efficacy of TM Biocontrol-1 through temperature variation with elevation heterogeneity among plots.

Multi-year Evaluation of Verbenone Plus Sanitation to Reduce Mountain Pine Beetle Attacks of Lodgepole Pine in California, Colorado, Idaho, and Wyoming

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The antiaggregation pheromone verbenone is operationally tested in three separate studies. The first lasted five years (2000-2004), designed to operationally to deter mass attack by the mountain pine beetle (MPB) on lodgepole pine in campgrounds and administrative areas surrounding Redfish and Little Redfish Lakes at the Sawtooth National Recreation Area in central

Idaho. Each year, five-gram verbenone pouches were placed in an even distribution (approximately 10m apart) within seven of fourteen 0.2 ha plots. During the first two years of the study a median of 12% of the host trees >13cm dbh were attacked and killed on the treated plots, whereas trees on the untreated plots incurred a median mortality of 59%. When approximately 50% of the trees on the untreated plots were killed a detectable beetle response to verbenone on the treated plots dramatically declined. After five years, MPB had killed a median of 87% of the lodgepole pine trees >13 cm in untreated plots and 67% in plots containing verbenone pouches.

In 2005, a second study was initiated to evaluate verbenone pouch with a larger dose of semiochemical. To evaluate the performance of verbenone over the duration of an MPB outbreak, we established twelve one-acre plots in central Idaho, and in northern Utah. Six plots at each locale were randomly chosen for verbenone treatment. Twenty, 7.5g verbenone pouches were evenly distributed within the 1-acre plots on the north facing side of the trees from 2005-2011. The remaining six plots at each location were used as untreated checks for comparison. For two years prior (2003 and 2004) to the placement of 7.5g verbenone pouches, cumulative, beetle-caused mortality was similar among the study plots within location. After treatment with verbenone, beetle populations were increasing at a faster rate in untreated areas than areas treated with verbenone pouches in the Utah plots. The rate of attack was similar between treatments in Idaho, however cumulative mortality averages near 10% less.

Studies have demonstrated that sanitation combined with verbenone results in significantly fewer beetle killed trees than verbenone alone. Removal of competing pheromones by removing infested trees may reduce the immigration of mountain pine beetle into the treated areas. Because MPB outbreaks occur over a period of five or more years, this study is designed to test the ability of silvicultural sanitation and verbenone for the duration of a mountain pine beetle outbreak. To evaluate the performance of verbenone and sanitation over the duration of an MPB outbreak, our third study established twelve one-acre plots in northern California, central Idaho, northwestern Wyoming, and at 2 locations in Colorado. Six plots at each locale were randomly chosen for verbenone treatment. Forty 7.5g verbenone pouches were evenly distributed within the 1-acre plots on the north facing side of the trees in 2009-2011. The remaining six plots at each location are used as untreated checks for comparison. Following a survey of verbenone treated plots, all trees infested with MPB within plots treated with verbenone will be removed prior to the flight of the beetles.

Inundative Release of *Aphthona* spp. Flea Beetles (Coleoptera: Chrysomelidae) as a Biological "Herbicide" on Leafy Spurge (*Euphorbia esula* L.) in Riparian Areas

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Inundative releases of beneficial insects are frequently used to suppress pest insects, but not commonly attempted as a method of weed biological control because of the difficulty in obtaining the required large numbers of insects. The successful establishment of a flea beetle com-

plex, mixed *Aphthona lacertosa* and *A. nigriscutus* (87 and 13%, respectively), for the control of leafy spurge (*Euphorbia esula* L.) provided an easily collectable source of these natural enemies that enabled us to attempt inundative release as a possible leafy spurge control method in a sensitive riparian ecological zone where chemical control is restricted. Our target weed populations were small isolated patches of leafy spurge along three streams in southwestern, central and northeastern Idaho. This study assessed leafy spurge and associated vegetation responses to inundative releases of 10 and 50 beetles per spurge flowering stem over two consecutive years. Releasing 10 beetles per flowering stem had inconclusive effects on spurge biomass, crown, stem, and seedling density. Alternatively, releasing 50 beetles per flowering stem resulted in a reduction of biomass, crown and stem density in the range of 60 to 80% at all three study sites, and about a 60% reduction of seedling density at one site, compared to untreated plots. In contrast to leafy spurge, associated vegetation did not conclusively respond to beetle release, indicating that it may take more than two years for desired riparian vegetation to respond to reductions in leafy spurge competition.

Ambrosia Beetle Habitat Use, Host Use, and Influence on Early Wood Colonizing Microbes in an Oak-Hickory Forest

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Ambrosia beetles are wood boring insects that vector, cultivate, and consume fungi. Most ambrosia beetle species are host generalists and attack dead, dying and stressed trees; and there are at least 20 non-native ambrosia beetle species that pose a risk to North American forests because of their potential to transmit tree pathogens. We characterized the ambrosia beetle community in an oak-hickory forest in central Missouri and examined ambrosia beetle resource use. Additionally, we explored how ambrosia beetles affect fungal colonization of dead wood. Over a two year period, we trapped 7 exotic and 13 native ambrosia beetle species. Exotic beetles accounted for 87% of the total abundance of all individuals, and there were more ambrosia beetles found in older forests (>69 years of age) versus young (<24 year old) forests, notably, exotic *Xyleborinus saxeseni* and *Xyleborus californicus* beetles. Native species abundance increased with structural characteristics associated with older stands. In coarse woody debris, we found that native and exotic ambrosia beetle species occupied the same pieces of dead wood. Use of dead wood by the native component increased with the size of dead wood. In ambrosia beetle galleries, we found a greater fungal diversity and richness of fungi initially than in wood that had no galleries. Over a year, however, the wood without galleries had equal fungal diversity and richness as the gallery wood. The predominant fungi collected from galleries included *Fusarian solani*, *Ambrosiella* spp., *Aspergillus* spp., *Penicillium* spp., *Sporothrix* spp., and *Trichoderma* spp. The percentage of fungal isolates with cellulose, hemicellulose, and lignin wood decay enzymes was similar in wood with and without galleries. It is clear that ambrosia beetles alter the diversity and abundance of fungi, at least initially, and could potentially change the structure of the fungal community in dead wood. Ambrosia beetles do not, however, affect the type of wood decay during the first year but they may have an indirect influence over time on decay by altering the exposure of wood to decay.

Of Maps and Gadgets: Managing Information in Large-Area Gypsy Moth IPM

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The National Gypsy Moth Slow the Spread Project (STS) is a large federally funded IPM program whose goal is to slow the rate of spread of this invasive pest from an historical average of ~20 km per year to an annual rate of 10 km or less. A critical component of the STS project involves managing and analyzing annual survey data with regard to assessing project efficacy as well as planning subsequent year's activities. Not surprisingly, the information systems component of the project has evolved in parallel with implementation of the actual pest management operations. The STS information system relies upon predictive modeling, enhanced field data collection tools, and integrated database and geographic information systems throughout the project yearly cycle. This poster describes the current state of the STS project information system with emphasis on the application of spatial data management tools in decision support, user support, data collection, and project planning.

Creeping Northward: Latitudinal Range Shifts of Mountain Pine Beetle in Western Canada

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{No abstract submitted.}

Are the Introduced Parasites of Larch Casebearer (*Coleophora laricella*) Still Present in the Blue Mts., Oregon?

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The larch casebearer (*Coleophora laricella* (Hubner)) is a non-native insect that has impacted western larch (*Larex occidentalis* Nutt.) in its native range. Control was attained through a biological control program that introduced 7 species of parasitoid wasps, but focused on *Agathis pumila* (Ratzeburg) (Hymenoptera: Braconidae) and *Chrysocharis laricinellae* (Ratzeburg) (Hymenoptera: Eulophidae). Roger Ryan studied the population biology of *C. laricella* before and after the introduction of parasitoid wasps and found that the parasites reduced the populations of larch casebearer from an average of over 50 moths/per 100 larch buds (fascicles) to an average of 1.6 larch moths/100 larch buds (10 yr averages pre- and post- introduction of parasitoid wasps). The biological control program is considered a major success story. Larch casebearer defoliation has been recently noted in the region and we sought to determine whether the parasitoid wasps are still present, and what impacts they are having on the larch casebearer. The last sample of parasitoid wasps in the Blue Mts. was taken in 1995. We used 13 core study sites of Ryan for detailed sampling of larch casebearer population status (number adult moths/100 western larch buds), parasitoid wasp species occurrence, and % parasitism of the larch casebearer caused by parasitoid wasps in June 2010. Ryan used 7 of these sites as release sites for *A. pumila* and 6 of these sites as check sites. However, one of these check sites for A. pumila was

used to release *Diadegma laricinellum*. To determine if *A. pumila* and other parasitoid wasps occur across the landscape, we sampled 16 additional locations at varying distances from these core sites. We recovered two species of introduced wasps from the 29 different sites, with the possibility of a third species. *Agathis pumila* was recovered from every site (29), *C. laricinellae* at fourteen sites, and *Cirrospilus pictus* at one site, although verification of *C. pictus* is still pending. Twelve native species of larch casebearer parasitoid wasps were found, although not as commonly as *A. pumila* or *C. laricinellae*. *Coleophora laricella* was found at all 29 sites. At the core thirteen Ryan sites, the mean density was 7.26 moths/100 buds compared to the 10-year average of 1.63 moths/100 buds ending in 1995. Percent parasitism ranged from 1.82% to 53.4%. Parasitism rates by *A. pumila* were also comparable to those reported by Ryan after successful introduction of parasitoids although not as high. Moth density was negatively correlated with percent parasitism by *A. pumila* ($p<.0001$); moth densities were lower where parasitism rates were high. *Agathis pumila* was the most abundant and widespread parasitoid wasp suggesting that it may continue to be an effective control agent of *C. laricella*.

Bark Beetle Outbreaks in Ponderosa Pine and Douglas-Fir Forests: Implications for Fuels, Fire, and Management

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Landscape-level bark beetle outbreaks have occurred throughout the western US during recent years in response to dense forest conditions, drought, and fire. Concerns about elevated fire hazard following these landscape level outbreaks and the vast expanses of high density stands have led to calls for forest and fuel treatments to decrease standing and surface fuels. Studies to date suggest that the impact of bark beetle outbreaks on stand structure and fuel profiles depends in part on forest type and time-since-outbreak (Jenkins et al. 2008). Yet, limited information is available for forest types such as ponderosa pine and it remains unclear how fuel reduction treatments might influence potential fire behavior following a bark beetle outbreak. Our study will provide insights for managing stands impacted from extensive bark beetle outbreaks in South Dakota and Wyoming. Objectives include quantifying stand structure and fuels in stands experiencing: a) high levels of bark beetle-caused ponderosa pine (Black Hills National Forest (NF)) and Douglas-fir (Big Horn & Shoshone NFs) mortality, b) high levels of tree mortality followed by sanitation or salvage logging dead trees, and c) no tree mortality. Preliminary results include: In the Black Hills NF, mountain pine beetle reduced basal area and tree density of ponderosa pine by 75-85%, resulting in nearly 200 snags per acre. Logging opened stand structures further and reduced snags to <2 per acre. Logging in the Black Hills NF tended to increase surface fuels in all classes (except 1000-hr rotten) and total fuel loadings compared with no mortality stands 3 years after attack. In the Bighorn NF, 3 years after logging in stands infested by Douglas-fir beetle, basal area, tree density, and snag density were reduced, and 100-hr fuels and total woody fuels were increased compared to infested stands without logging. The effects of bark beetle-caused mortality on forest stand structure, canopy fuels, and woody surface fuels can have highly variable and complex implications for fire behavior. More open stand structure resulting from reduced tree densities on our study sites can lead to greater wind speeds and

higher drying potential, but reduced potential for tree-to-tree fire spread. Increased woody surface fuels can support increased fire rate-of-spread and flame lengths. As snags continue to fall to the ground in the unlogged areas, we expect to observe large increases in surface woody fuels in the future. Future work will focus on summarizing data from the Shoshone NF and on re-measuring canopy and surface fuels on all 3 sites to explore how fuel complexes and the implications for fire behavior change over time following an outbreak, and how post-outbreak logging treatments modify these fuel complexes.

Behavioral Ecology of Host Selection and Colonization of the Asian Longhorn Beetle, *Anoplophora glabripennis*

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{No abstract submitted.}

Dispersal and Population Spread of the Asian Longhorn Beetle, *Anoplophora glabripennis*

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An Issue of Time: HWA Development and Host Plant Budburst Phenology – a Key to Resistance?

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Quantitative Analysis of Starch in Hemlocks Varying in Susceptibility to Hemlock Woolly Adelgid, *Adelges tsugae*: A Possible Mechanism for Resistance?

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Scaling the Direct and Indirect Effects of an Invasive Insect on Canopy Arthropod Biodiversity

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Honoring the Career of Peter Lorio, Jr.

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Hazard-Rating and Impact of the Nantucket Pine Tip Moth in Loblolly Pine Plantations of the Western Gulf Coastal Plain

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Orientation Behavior of Two Hemlock Woolly Adelgid Predators to Hemlock Woolly Adelgid, Host Tree Odors, and Other Tree Volatiles: a Multi-Chambered Olfactometer Assay

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Evaluation of a biological control agent requires understanding of the mechanisms employed by the agent to recognize the target organism, in this case the predator, *Laricobius nigrinus,* its prey, hemlock woolly adelgid (HWA) and its host, hemlock trees. Our objective was to provide information based on insect behavior to increase overall efficacy in the efforts to control HWA in hemlock forests in eastern United States. *L. nigrinus* responded to odors from HWA host trees, but not to odors from HWA. *L. nigrinus* reared on western hemlock has a strong preference for western hemlock volatiles, whereas those reared on eastern hemlock showed no preference. In February, *L. nigrinus* consistently flew rather than walked in the olfactometer suggesting a period of dispersal or mate finding at that time of year. These results have implications for programs to release *L. nigrinus* in the eastern U.S. for control of HWA.

Beyond Book Learning in Natural Resources: Cultivating Pedagogy of Service-Learning through International Partnerships

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The class focuses on arts, environmental challenges faced by people living in arid ecosystems, and creative solutions to those problems. This will be accomplished, in part, by traveling to Arad, Burlington Vermont's sister city in Israel. The student will work on service-learning projects, attend classes, lead meetings, and act as ambassadors of UVM, Burlington, Vermont, and United States. Service-learning is a form of experiential education in which students engage in activities that address human and community needs together with structured opportunities intentionally designed to promote student learning and development. Reflection and reciprocity are key concepts of service-learning. As such, students will work in partnership with community members in Israel to identify and address real community needs.

At the end of the course students will be able to:1) Identify and articulate roles of all the parties (the State of Israel, the Bedouin community, the cities of Tel Aviv, Jerusalem, Bethlehem, etc.)

involved around issues of water conflict in Arad, 2) Students will develop an increased sense of social responsibility and appreciation for diversity through an understanding of the social, political, religious, and cultural constructs of the host community, 3) Analyze how the issue of water scarcity amplifies complex socio-economic, political, and religious struggles in the region, 4) Identify and describe the creative and functional uses of available resources by communities in this part of the world (e.g. trash), 5) Define the terms "environmental justice" and "sustainability" and describe how they relates to water scarcity issues in this part of the world, 6) Design, implement and evaluate projects in partnership with community members from the region to meet an identified community need, and 7) Demonstrate an ability to reflect on experiences in relation their role as citizens and environmentalists. Through realistic self-appraisal and reflection, students will demonstrate personal growth through clarification of values and enhanced self-esteem. Students will learn how their intended career choices may be viewed or practiced in different cultural contexts.

Emergence Cages: An Effective Tool to Assess Emergence of *Laricobius* spp. in the Southern Appalachians?

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In 2010, a study was initiated to evaluate the use of emergence traps to assess emergence of *Laricobius nigrinus* in two locations (Blackberry Farm, Walland, Tennessee and Elkmont, Great Smoky Mountains National Park) where this predatory beetle was released against hemlock woolly adelgid (*Adelges tsugae*). The emergence of *L. nigrinus* was observed from 12 October to 2 December 2010. Additionally, adults of *Laricobius rubidus* (a predatory beetle native to the eastern U.S.) were collected from traps at Blackberry Farm and Elkmont. No differences were observed between numbers of *L. nigrinus* collected from inner vs. outer traps on any sampling date (ANOVA: $F_{(10, 242)} = 0.82$, $P = 0.6055$). No adults of either *Laricobius* species were collected in bole traps, which suggests *Laricobius* fly directly to the canopy following emergence. More *L. nigrinus* were collected from lower beat samples than upper beat samples at Elkmont, and one adult *L. rubidus* was collected from a beat sample at Elkmont on one sampling date. Two adult *L. nigrinus* were collected in beat samples at Blackberry Farm on two sampling dates. The average density of *L. nigrinus* at Elkmont was 5.6 beetles/m^2, and the average number of beetles estimated under study tree canopies was 328.6. The density of *L. nigrinus* under the study tree at Blackberry Farm was 23.8 beetles/m^2, and 719.8 beetles were estimated occurring under the canopy. Emergence traps are an effective tool to assess emergence of *L. nigrinus*, and this technique may be useful in future studies to detect and quantify populations of *L. nigrinus* in areas of release.

Preserving the Past for the Future: Capturing Forest Insect and Disease Gray Literature

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{No abstract submitted.}

Lodgepole Pine Following Mountain Pine Beetle Epidemics: Fuel for Fire???

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Over the last 30 years, more than a million acres of lodgepole pine (Pinus contorta Dougl. ex. Loud) in south-central Oregon have experienced extensive mortality from mountain pine beetle (Dendroctonus ponderosae Hopkins) (MPB). This extensive mortality has raised questions about the potential for catastrophic wildfire. Although there is a major concern about fire behavior following widespread tree mortality caused by MPB, previous research has provided equivocal evidence concerning the influence on temporal and spatial aspects of fuels and potential fire behavior. In lodgepole pine dominated forests of south-central Oregon, we hypothesize that following MPB epidemics several stages will occur in which surface, ladder, and crown fuels will change and alter wildfire behavior. Initially, an increase in potential for large crown fires may occur due to remaining dead needles in the canopy. As needles fall off dead trees and before trees begin to fall, crown fire potential is reduced. When dead standing trees and branches begin to fall, and regeneration of understory shrubs and trees initiate, surface fire severity will increase. The magnitude of change in both fire behavior will be dependent on forest productivity and tree regeneration. To address these hypotheses we combine field measurements and fire behavior systems.

Early Results of Host Tests of *Leptoypha hospita* (Hemiptera: Tingidae): a Potential Biocontrol Agent of Chinese Privet

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Here we report on no-choice host specificity tests of a lace bug (*Leptoypha hospita* Drake et Poor), a potential biological control agent of the invasive plant Chinese privet. Feeding damage, number of eggs deposited, and adult emergence were compared among 21 test plant species, which were selected based on the centrifugal phylogenetic method. Six of 21 plant species showed no feeding damage, no egg deposition, and no adult development. Lace bugs fed on 14 plant species, laid eggs on 11 species, and 11 supported development of nymphs to adulthood. In most cases *L. hospita* did better on Chinese privet but this was not the case with *Forestiera acuminata* and *F. neomexicana*. For *F. acuminata* feeding damage was high and they laid equal numbers of eggs but development of nymphs was lower than on privet. The lace bugs did equally well on *F. neomexicana* and Chinese privet. European privet, *L. vulgare* also an exotic invasive, was similar to Chinese privet in suitability. In no-choice tests the host range of *L. hospita* was restricted to plants in the tribe Oleeae, which also contains Chinese privet. Species that supported nymphal development may be in the fundamental host range of *L. hospita*, but multiple-choice tests are needed to determine if these hosts are used when Chinese privet is available. Further testing should help determine the potential of *L. hospita* as a biocontrol agent of Chinese privet.

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