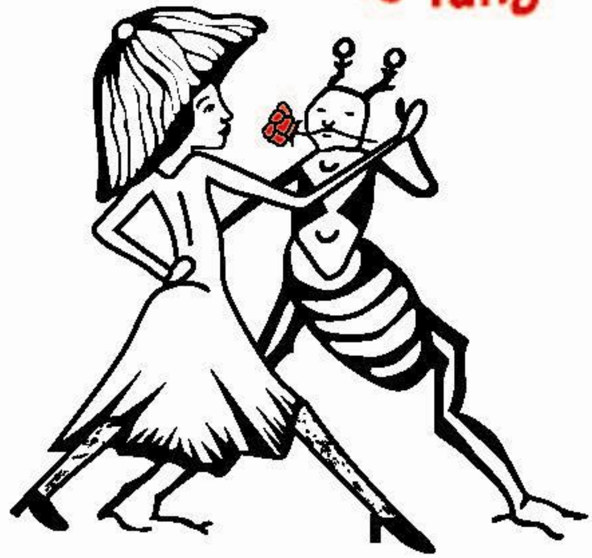
64th Western Forest Insect Work Conference
Coeur d'Alene, ID
March 4-7th, 2013

Disclaimer

The contents of these proceedings are not available for citation or publication without the consent of the author. Articles may have been reformatted, but were printed approximately as submitted.

Authors are solely responsible for content.

It Takes Two to Tango



WFIWC 2013 – Coeur d'Alene, ID

TABLE OF CONTENTS

Western Forest Insect Work Conference Officers as of March 3rd, 2013

Executive Committee

Chair	Rich Hofstetter
Past Chair	Kathy Sheehan (2010)
Secretary	Laura Lazarus
Treasurer	Karen Ripley
Councilor	Glenn Kohler
Councilor	Steve Cook
Councilor	David Jack

Common Names Committee: Brytten Steed (co-Chair), Bill Ciesla (co-Chair), Beverly Bulaon, Bobbie Fitzgibbon, Lee Humble, Lee Pederson, Iral Ragenovich

Founder's Award Committee: Barbara Bentz (Chair), Joel McMillin, Ken Raffa, Steve Seybold

History Committee: Mal Furniss (co-Chair), Sandy Kegley (co-Chair), Boyd Wickman (co-Chair)

Memorial Scholarship Committee: Darrell Ross (co-Chair), Sandy Kegley, Steve Munson, Steve Seybold, Ward Strong

Memorial Scholarship Fundraising Committee: Monica Gaylord (Chair), Steve Burke, Jennifer Burleigh, Steve Cook, Ladd Livingston, Kjerstin Skov

adhoc Technology Committee: Joel Egan (co-Chair), David Jack (co-Chair)

Program Committee for the 64th Annual WFIWC Meeting: Joel Egan (Chair), Steve Cook, Diana Six, Amy Gannon, Chris Hayes, Nancy Sturdevant, Scott Sontag

Local Arrangements Committee for the 64th Annual WFIWC Meeting: Sandy Kegley (Chair), Nancy Sturdevant, Lee Pederson, Tom Eckberg, Gina Davis

Proceedings: Chris Hayes

PROGRAM AGENDA

Monday March 4th, 2013

1300 - 1800	Registration Open
1600 - 1700	Executive Committee Meeting
1800 - 2000	Opening Social and Mixer

Tuesday March 5th, 2013

0700 – 1000	Registration open
0800 – 0815	Welcome to Coeur d'Alene
0815 – 0845	History Committee Presentation
	"The Remarkable Characters of the Coeur d'Alene Forest Insect Field Station 1919-1955" **Sandy Kegley** and Malcolm Furniss
0845 – 0945	Plenary Session #1 – Joel Egan moderator
	"Inseparable? Symbiotic complexes in biology, ecology and pestilence" **Kier Klepzig**, Asst. Research Director, U.S. Forest Service
	"Multiple disturbance interactions within range-wide restoration of whitebark pine" **Robert Keane**, Research Ecologist, U.S. Forest Service
0945 – 1015	Break
1015 – 1045	Memorial Scholarship Presentation – Darrell Ross moderator
	"Bringing together ecology and evolution to better understand bark beetle-fungal symbioses" **Ryan Bracewell**, Ph.D. Candidate, University of Montana
1045 – 1130	Silvicultural Perspective on Future Forests and Mgmt.
	"Priority Setting for Restoration in the face of Interacting Stressors" **Barry Bollenbacher**, Regional Silviculturist, U.S. Forest Service
1130 – 1215	Initial Business Meeting
1215 – 1345	Lunch (on your own)

Tuesday March 5th, 2013 (continued)

1345 – 1515 Concurrent Workshops - Session #1

Bark Beetle Symbioses
Haydeé Peralta moderator

> "It takes two (or more) to tango: influence of phoretic mites on bark beetle-fungal relations"
> **Richard Hostetter**, Northern Arizona University

> "Sometimes it takes more than two to tango: Spruce beetle multi-partite symbioses"
> **Yasmin Cardoza**, North Carolina State University

> "Tango, Square Dance, or Rave: Organismal Interactions at Bark Beetle Transformed Habitat"
> **Jesse Pfammatter**, University of Wisconsin

Insects and Pathogens in Whitebark Pine
Steve Cook moderator

> "Whitebark Pine after Mountain Pine Beetle Outbreaks: Current Conditions and Regeneration"
> **Kendra Schotzko**, University of Idaho

> "Comparison of whitebark and lodgepole pine defenses against the mountain pine beetle"
> **Celia Boone,** University of northern British Columbia

> "Comparing past and present outbreaks of mountain pine beetle in whitebark pine"
> **Dana Perkins**, Bureau of Land Management

> "Blister rust and small whitebark pine – can they co-exist?"
> **John Schwandt**, U.S. Forest Service

New Directions in Bark Beetle Pheromone Research and Development
Darrell Ross moderator

> "New insights into bark beetle host chemoreception"
> **Dave Wakarchuk**, Synergy Semiochemicals Corp.

> "The desire to get close…but not too close: the multifunctional semiochemicals of bark beetles"
> **Brian Sullivan**, U.S. Forest Service

> "Bark beetle pheromone research to support technology development"
> **Darrell Ross**, Oregon State University

1545 – 1700 Graduate Student Session #1
Brytten Steed moderator

"Resource allocation, primary sex ratios and mortality in mountain pine beetle broods"
Leanna Lachowsky and Mary Reid

"The impact of mountain pine beetle on foliar moisture content and fuels in whitebark pine stands in Wyoming and Montana"
Chelsea Toone and Michael Jenkins

"What mountain pine beetles could learn from tree acoustic emissions"
Mathias Kaiser and Mary Reid

"Effects of host constitutive alpha-pinene content on epidemic mountain pine beetle secondary attraction"
Jordan Lewis Burke and Allan Carroll

1730 – 1815 Costello Fun Run

1900 – 2100 Poster Session w/ Ice Cream Social, Silent Auction, and Photo Contest

Wednesday March 6th, 2013

0700 – 1000 Registration open

0800 – 0900 Graduate Student Session #2 – Brytten Steed moderator

"Physiological impacts to Pinus ponderosa following colonization of bark beetles and their associated fungi"
Stephen J. Burr, Thomas E. Kolb, Richard W. Hofstetter, & Monica L. Gaylord

"Stand response to western spruce budworm defoliation and mortality in northern New Mexico, USA"
Adam Polinko and Kristen Waring

"Quantifying arthropod diversity in the Selkirk Mountains of northern Idaho and eastern Washington"
Laine Smith, Stephen Cook, Michael Lucid and Sam Cushman

0900 – 1000 Plenary Session #2 - Steve Cook moderator

"The bark beetle – fungus contrapasso: When it takes three to tango, who leads?"
Diana Six, Professor of Forest Entomology and Pathology, University of Montana

"The dance between adelgids and their hosts"
Fred Hain, emeritus Professor of Entomology, North Carolina State University

1000 – 1030 Break & Photos

1030 – 1200 Concurrent Workshops - Session #2

Spatial Analysis of Forest Insects
Jeff Hicke moderator

"Early Detection and Modeling of Mountain Pine Beetle Spread with Space-Time Dependent Environmental Predictors"
Zachary A. Holden, U.S. Forest Service, Erin Landguth and Jordan Purdy, University of Montana

"Slow Down, Bring your Friends, and Eat a Tree: How Phenology and Differential Dispersal Predict Landscape Patterns of Mountain Pine Beetle Impact"
James Powell, Utah State University and Barbara Bentz, U.S. Forest Service

"Spatial Genetic Structure of the Mountain Pine Beetle in Western North America"
Celia Boone, University of Northern British Columbia

"Spatial and Temporal Patterns of Mountain Pine Beetle-Caused Tree Mortality in Northcentral Colorado Using Landsat Imagery"
Arjan J. H. Meddens, University of Idaho

Basic ecological approaches to understanding bark beetles
Diana Six moderator

"Estimating surface and canopy fuel conditions after mountain pine beetle outbreaks in northern Rocky Mountain ecosystems"
Robert Keane and Brian Izbicki, U.S. Forest Service

"The influence of bark beetle infestation on fuel loadings and fire behavior in southwestern ponderosa pine"
Matt Hansen, U.S. Forest Service

"Geographic variation in mountain pine beetle development and productivity: implications for spread into new habitats"
Katherine Bleiker and GD Smith, Canadian Forest Service

"Condition-dependent responses to tree quality of mountain pine beetles"
Mary Reid, University of Calgary

"The effects of tree chemistry and beetle chemical legacy on growth of a fungal mutualist"
Thomas Seth Davis, University of Idaho/University of Montana

"The kids aren't alright: identifying the cause of hybrid male sterility in the mountain pine beetle"

Ryan Bracewell, University of Montana

Defoliator Management and Biocontrol
Tom Eckberg moderator

"Egg parasitoids and viral incidence in Douglas-fir tussock moth populations"
Steve Cook, University of Idaho

"Spreading the Virus: What have we learned about controlling Douglas-fir tussock moth"
Connie Mehmel, U.S. Forest Service

"Persistence of introduced parasitoid wasps used for biocontrol of larch casebearer in western larch forests."
Mailea Miller-Pierce, David Shaw, Ari DeMarco, and Paul Oester

"New Rules: Defoliator suppression programs and the Clean Water Act-Idaho's 2012 Experience"
Tom Eckberg, Idaho Department of Lands

1200 – 1700 Field Trips (lunch provided)

1800 – 2200 Founders Award Banquet

Thursday March 7th, 2013

0800 – 0845 Final Business Meeting

0845 – 1015 Concurrent Workshops - Session #3

Beyond the National I&D Risk Map: charting a course forward
Eric Smith moderator

This session will summarize the procedures and results of the 2012 National Insect and Disease Risk Map and present how the results and the component data layers can be used in future projects and analyses at national and regional scales. The session will include a group discussion of opportunities and needs for integration with ongoing applications.

Ambrosia beetles – the 'new' big threat
Tim Paine moderator

"Ambrosia beetle systematics and new invasions"
Bob Rabaglia, U.S. Forest Service

"Impact of the Polyphagous shot hole borer, *Euwallacea* sp., in the forests of southern California."
Tom Coleman, U.S. Forest Service

"Polyphagous shot hole borer potential threat to urban forests"
Tim Paine, University of California Riverside

"Basic and Applied Research toward management of *Xyleborus glabratus*, vector of laurel wilt"
Jorge Pena, University of Florida

"Host Attraction of Redbay Ambrosia Beetle and Development of Essential Oil Lures"
Jim Hanula, U.S. Forest Service

Ski Area Management: Forest Health Challenges and Opportunities
Nancy Sturdevant moderator

"Ski Area Management: Forest Health Challenges and Opportunities"
Nancy J. Sturdevant, U.S. Forest Service

"Colorado Ski Areas in Bark Beetle Country"
Bob Cain and Tom Eager, U.S. Forest Service

"Ski Area Conundrum: A case study of June Mountain Ski Area, Inyo National Forest, Mono County, California"
Beverly M. Bulaon and Martin MacKenzie, U.S. Forest Service

"Sun Valley's Success with Pheromones Following Wildfire"
Laura Lazarus, U.S. Forest Service

"My Experience Managing Bark Beetle Survey and Suppression Crews on Steamboat Ski Area from a District Perspective"
Carl L. Jorgensen, U.S. Forest Service

1015 – 1045 Break & Photos

1045 – 1215 Concurrent Workshops – Session #4

How did you choose the susceptible host? ... I didn't. The susceptible host chose me. The effect of changes in host susceptibility on insect response. Paraphrased: "The Tango lesson"
Andy Graves moderator

"The role of drought and goldspotted oak borer injury on oaks in southern California"
Tom Coleman, U.S. Forest Service

"Interactions among drought, tree stress, and bark beetles in forests and woodlands of the southwestern U. S."
Thomas Kolb and Monica Gaylord, Northern Arizona University

"The role of abiotic and biotic stressors in Jeffrey pine susceptibility to bark beetles"
Nancy Grulke, U.S. Forest Service

<u>Defoliators and beetle/defoliator interactions</u>
Laura Lazarus moderator

"Pine butterfly and subsequent western pine beetle and other bark beetle outbreaks"
Dave Shaw, Oregon State University

"Western spruce budworm and subsequent bark beetle outbreaks"
Beth Willhite, U.S. Forest Service

"Western spruce budworm and subsequent Douglas-fir beetle outbreaks"
Nancy Sturdevant, U.S. Forest Service

<u>The Bark Beetle Technical Working Group:</u>
Continuing a Discussion of Needs, Assessments, and Research Priorities
Chris Fettig and Carl Jorgensen moderators

Moderators will lead an informal forum to discuss the status and future of BBTWG, BBTWG needs assessments, and research priorities, and other bark beetle-related issues.

1215 – 1415 Lunch Cruise along Lake Coeur d'Alene

1415 – 1430 Return from Cruise

1430 – 1600 Concurrent Workshops – Session #5

<u>Post-epidemic: What we wish we knew then / what we think we know now</u>
Danielle Reboletti moderator

"Interactions between bark beetle-caused tree mortality and stem diameters in western U.S. yellow pine forests"
Joel M Egan, U.S. Forest Service

"Will outbreak MPB impact adjacent alternate pine hosts? MPB-caused mortality and host preference between lodgepole and ponderosa pines in Colorado"
Daniel West, Colorado State University

"Impacts of outbreaks on forests and communities"
Chris Fettig, U.S. Forest Service

Western North American Defoliators WG: Where do we go from here?
Kathy Sheehan moderator

Enhancing entomology photography skills and Bugwood technologies update
Bill Ciesla and Keith Douce moderators

"Photography for Forest Health Specialists"
William Ciesla, Forest Health Management International

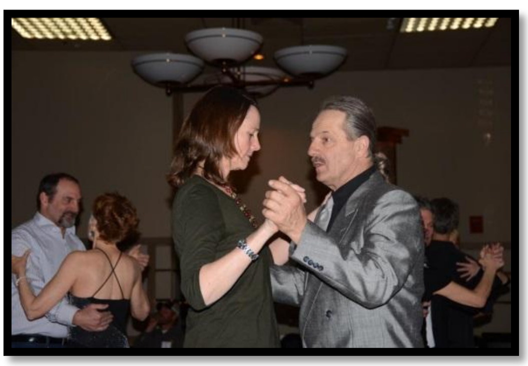
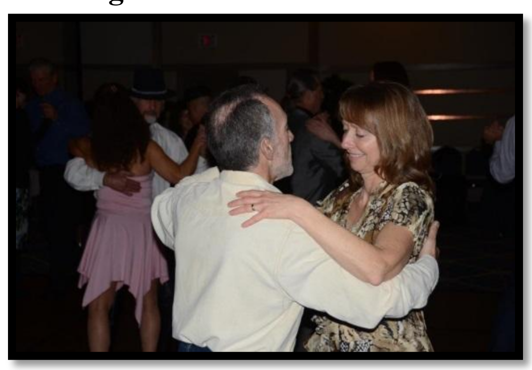
"Integrating Mobile Apps, Wikis, Image Systems and partnerships to advance invasive species, forest health & forestry education: Bugwood Center Update"
Keith Douce, University of Georgia

Regional Insect Conditions Reporting
Cyndi Snyder moderator

Workshop will cover insect activity and trends by geographic Region that took place in 2012.

1600 Meeting Adjourns

It Takes Two to Tango…

Executive Business Meeting Notes
March 4, 2013
Coeur D'Alene

Opening comments
Rich Hofstetter asked for introductions of committee members.
Members present: Brytten Steed, Joel Egan, Darrell Ross, Nancy Sturdevant, Sandy Kegley, Bill Ciesla, Karen Ripley, Glenn Kohler, Laura Lazarus, and Steve Cook. Barbara Bentz was absent
.

Old Business
1. Minutes from last year's executive committee meeting were read by Laura Lazarus. Minutes are accepted from last year by Joel Egan, Bill Ciesla seconded the nomination.
2. Sandy Kegley said there are 138 people registered for the meeting, twenty-four of them students and an additional seven coming to the banquet only. She doesn't have all of the bills in yet so there was no total cost report.
3. Local Committee Report
    a. Sandy Kegley asked if the proceedings are posted to the website. Darrell says you may have to archive them to the University of Idaho website.
    b. Joel Egan said that Chris Hayes volunteered to get all of the meeting abstracts together this spring while he has time.
    c. Information about registration will be announced tomorrow.
    d. Alan Carol and Dana Perkins were unable to attend, so they had to cancel their sessions and talks.
    e. The last meeting held in CDA was 1990 and 1969.
    f. Lee Pederson, Nancy Sturdevant, Doug Wolf, Candee Wilfong, Chris Hayes, and Tom Eckberg are the local committee.
    g. Amy Gannon, Diana Six, Joel Egan, and Scott Sontag are the Program Committee.
    h. Gina Davis is in charge of photo contest.
4. Rich's list of members that passed away include: Gene Amman, Don Cahill, Scott Costa, Emmett Wilson, Arnold T. Drooz. The list of retirees includes: Nancy Gillette, Roger Burnside, and Bob Garrett.
5. Scholarship committee report was read by Steve Cook.

This year's silent auction will be held Tuesday night. Submit donations to Steve Cook. Two companies bought tables, so there will be $ 400 dollars going into it. Steve has a $50 donation from past members; Karen will take those checks and makes a receipt. Karen keeps track of Canadian donations and records them at a later date.

6. Treasurer's report-Karen Ripley read her report.
7. Common Names Committee report-Brytten Steed read the report. Remember to work on submitting an insect list while working on Western Forest Insect book updates, i.e. make submissions for a group of insects at a time. Bill suggested developing a simpler process to encourage folks to submit. ESA and ESC have websites detailing the process.
8. Darrell Ross read the Memorial Scholarship Committee report. They received two applications for 2013.
9. Founders Award Committee report was read by Rich.
10. History Committee-Sandy Kegley read the report.
11. Ad hoc Committee- Joel read the report. They were able to put the Founder's Award talk on the website from the two presentations in 2012. It took a day to do the splicing and put the talks together for the website.

<u>New Business</u>

New motions:

1. Karen should get estimates of costs to work with an accountant to review accounts to make sure that they are consistent with a tax exempt organization and get back to Rich. Brytten moved on the motion, Rich seconded the motion.
2. Barbara Bentz suggested that changes be made to the Founder's Award Bylaws. The first change is that committee members will be allowed to nominate candidates. The second change is that the chair will now be eligible to vote. Darrell moved on the motion and Bill Ciesla seconded the motion.

Other things discussed:

3. Karen suggested Adding Laura and Rich to the signature card for banking, no motions needed.
4. Joel Egan suggested that the Ad hoc Committee fulfilled their charter and should absolve into the Founders committee or have a separate committee to deal with technology. No motion was made.
5. At Karen's suggestion, we discussed keeping the yearly meeting funds in a CD. We all thought this was a good idea because this is not an investment; we are just keeping the money for the next meeting.
6. Sandy asked what we thought about soliciting new members for the Historical Committee to work with Mal and Boyd. No motion was made.
7. Sandy asked what we thought about buying portable microphones for speakers. We all agreed that the meeting organizers should make that call and rent or buy them based upon needs and then incorporate the costs into the registration fee.
8. Rich mentioned the donations to memorials of members that passed away. They are listed in Karen's treasurer's report
9. A new counselor is needed to replace Steve Cook for 2013.
10. A new WFIWC chair is needed. Kathy Sheehan, Glenn and Rich will talk to people about it.
11. We discussed 2014 and 2015 meeting locations. Darrell thinks we should not strong arm people, rather, leave it up to those that volunteer happily to do it. He may host the 2014 meeting.
12. Brytten motioned to end meeting, Sandy seconded the motion.

1ST ANNUAL COSTELLO FUN RUN

Final Executive Business Meeting Notes
March 4, 2013
Coeur d'Alene

Old Business –opened by WFIWC Chair, Rich Hofstetter

1. IUFRO meeting will be held in Banff, Canada, September 16-19, 2013.
2. Glenn Kohler has sign-up sheets for WA pesticide certification credits, see him if interested.
3. Steve Cook announced that the auction proceeds totaled over $800.00.
4. Glenn Kohler announced that the counselors checked the books and everything is as it should be.
5. Rich thanked the hotel for excellent accommodations.

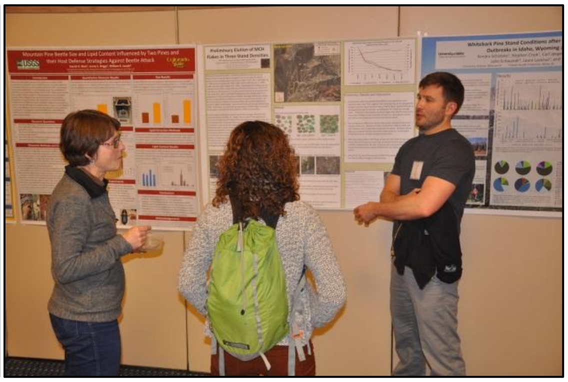
New Business

New motions:

1. Region 5 will host the 2014 WFIWC meeting. A motion was made by Connie Mehmel and the motion was accepted.
2. A motion was made by Dwight Scarbrough to have Andy Graves check on the availability of Region 3 to host the 2015 WFIWC in Taos, New Mexico. The motion was accepted.
3. Counselor position nominations were Dwight Scarbrough, Rob Flowers, Gina Davis, Sky Stevens, Katherine Bleiker, and Diana Six. We voted and the winner was Katherine Bleiker.
4. Chair position nominations were Steve Cook and Diana Six. We voted and Steve Cook is the new Chair.

Other things discussed:

5. Sandy announced the lunch cruise departure time and location.
6. Kathy Sheehan thanked Rich for his wonderful service and we all agreed with applause.
7. Rich passed the gavel and rubber stamp to the new chair, Steve Cook.
8. Motion to end the meeting was made by Andy Eglitis and a second motion by Kathy Sheehan, with motion accepted.
9. Meeting adjourned 0826.



FOUNDERS AWARD

The 2012 Founders Award was presented to Ken Gibson for his outstanding contributions to forest entomology in the west. Ken's acceptance speech can be viewed online at http://www.fsl.orst.edu/wfiwc/awards/2013-founders.htm

MEMORIAL SCHOLARSHIP PRESENTATION
Darrell Ross moderator

Bringing together ecology and evolution to better understand bark beetle-fungal symbioses.

Ryan R. Bracewell
University of Montana, Missoula, MT

Symbiotic relationships between insects and microbes abound in nature. However, how these relationships form, function and are maintained through time is often poorly understood. This is especially true when considering bark beetle-fungal symbioses. The western pine beetle (*Dendroctonus brevicomis*) is a significant pest in western North America, yet has a poorly understood relationship with symbiotic fungi. To better understand this symbiosis, sampling of the mycangia of beetles from 29 geographically distinct locations was undertaken. I find overwhelming evidence of widespread fidelity in this system as *Entomocorticium* sp. B and *Ceratocystiopsis brevicomi* are the primary mutualistic fungi. Scanning electron microscope images conclusively demonstrate that these fungal species are abundant in larval tunnels in the bark and are likely heavily fed upon by developing larvae. Field based surveys conducted at two sites in Montana show that beetles carrying *Entomocorticium* sp. B are more abundant and on average larger than beetles carrying *Ceratocystiopsis brevicomi*. Draft genomes for *Ceratocystiopsis brevicomi* and *Entomocorticium* sp. B are being assembled and analyzed for insights into the life cycle of these fungi. Restriction associated DNA sequencing is underway of both beetles and fungi from all collection areas which will also allow for population structure and cospeciation patterns to be clarified. In total, these combined ecological and evolutionary insights into the western pine beetle-fungal symbiosis suggest that this insect-fungal relationship is conserved over space and time and that one of the fungal symbionts is likely a better partner.

PLENARY SESSION #1
Joel Egan moderator

Inseparable? Symbiotic complexes in biology, ecology and pestilence

Kier D. Klepzig
USDA Forest Service, Asheville, North Carolina

The definition of symbiosis can be wordy and confusing. Trying to describe what this interaction means in forests can be even more so. Studies of the interactions between tree killing beetles and their microbes are fraught with complications and difficulties, whether in the field or in the lab. Interactions can change due to temperature, population dynamics, tree defenses and the influence of other passengers associated with the beetle vector. The role (if any) of these fungi in damaging, sickening or killing trees seems to be especially controversial. This becomes even more the case when considering insects and fungi associated with declines. While the intricacies and evolution of symbiotic complexes in forests can be academically interesting, the management implications of such questions puts a different lens on the study of these complex and important organisms.

Addressing multiple disturbance interactions in the rangewide restoration of whitebark pine

Robert Keane, USDA Forest Service, Rocky Mountain Research Station, Missoula Fire Sciences Laboratory, Missoula, MT

Whitebark pine (*Pinus albicaulis*), a keystone species in upper subalpine forests of the northern Rocky Mountains and Cascades in the United States and Canada, is declining across most of its range because of combined and interacting effects of recent mountain pine beetle (*Dentroctonous ponderosae*) outbreaks, ongoing blister rust (*Cronartium ribicola*) epidemics, and advancing succession from fire exclusion. Projected climate warming appears to be exacerbating these disturbance agents causing the decline to accelerate and intensify in parts of whitebark pine's range. Many government agencies are initiating extensive efforts aimed at restoring these diverse and ecologically important forests. However, the key to successful and effective restoration is to mitigate the long-term effects of these disturbance interactions in restoration treatment design. This presentation will discuss the interacting factors that contribute to the decline of whitebark pine, and then present the range-wide restoration strategy that specifically addresses these interactions in its design. Then, an integrated suite of restoration actions will be presented to illustrate how whitebark pine forests will be restored in the face of dynamic disturbance interactions enhanced by climate change.

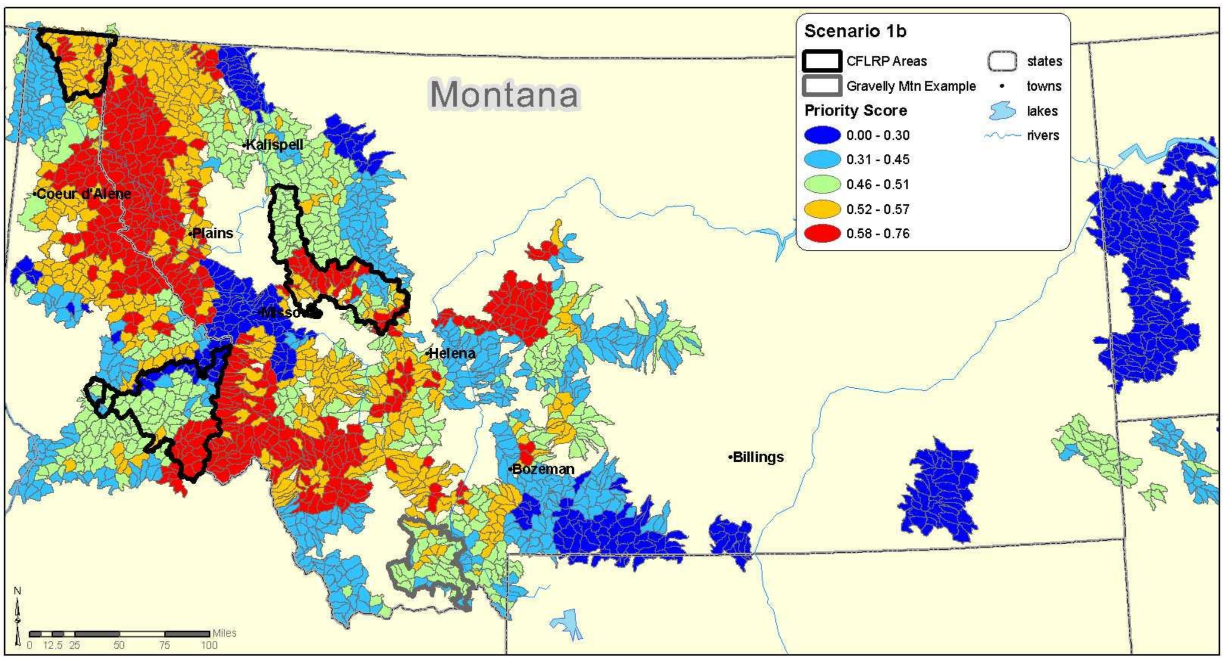
Priority Setting for Restoration in the face of Interacting Stressors

Barry L Bollenbacher
Regional Silvicuturist, Northern Region, Missoula MT

Discussion:

- Policy context
- What we currently think know about weather and climate, driver of disturbance
- What we know about vegetation departure, and vulnerability due to stressors
- Priority setting given values at risk using a Region One decision support tool with IRPS
- Priority opportunities relationship to bark beetles
  - What may be actions we can take

Spatial Answer to the Planning Question *Which forest areas may be most vulnerable to loss of important ecosystem elements and where may opportunities be to restore to a more resilient condition?*



http://www.fs.usda.gov/goto/r1/irps

PLENARY SESSION #2
Steve Cook moderator

The bark beetle – fungus *contrapaso*: When it takes three to tango, who leads?

Diana L. Six
Department of Ecosystem and Conservation Sciences,
The University of Montana, Missoula, MT

Bark beetle-fungus mutualisms typically contain three partners (a beetle and two fungi) in an interaction triangle that is predicted to be inherently unstable due to differential selection pressures, competition and cheating. This interaction can be likened to a three-way tango where each dancer attempts to take the lead. The dance is difficult enough with two partners that cooperate, but when three partners are involved, each with a different agenda, cohesion and function are put at risk. Yet despite competing agendas, many three-way bark beetle-fungus symbioses have existed in a stable state over long periods of evolutionary time. So what mechanisms support this stability? The answer lies in the music to which the symbiotic dance is performed and the degree of physical intimacy between the fungal partners. If the tempo varies and the partners are physically close, no one partner can dominate the lead, but instead dominance shifts from partner to partner over time, resulting in a contrapaso – the dancers move as one, locked together by their own individualistic responses to the music. With bark beetle-fungus mutualisms, the music that controls the dance is the temperature of the environment with the tempo set by variability in heat and cold over time and space. How close the dancers are to one another is determined by the attack density of the beetle partner. If the music does not exhibit the correct tempo or if the dancers drift too far apart, the mutualism tango unravels. In this talk I will describe three-way bark beetle-mutualisms, the tango of symbiotic stability, and how a warming climate may introduce sufficient discord into the delicate contrapaso such that these fascinating and important interactions may at risk.

The Dance Between Adelgids and Their Hosts

Fred Hain, Kelly Oten, Mary Talley and Micah Gardner
North Carolina State University, Raleigh, North Carolina

The hemlock woolly adelgid (*Adelges tsugae*) (HWA) is an exotic pest from Japan that threatens eastern and Carolina hemlock populations in more than 18 eastern states and kills tree in as little as 4 years. Within the infested area, 80-90% of all hemlocks are dead, frequently dying within 4 years. Before death, infested trees display symptoms of drought stress. Host resistance within eastern and Carolina hemlock is, at best, rare, while other hemlock species are considered moderate to very resistant. Electron microscopy reveals the intimate relations between the insect and its hosts. We examined feeding sites and behavior, analyzed and compare host surfaces, examined sheath material, and observed trichomes, cuticle thickness and epicuticular wax structure. Other interesting facts about HWA include the presence of endosymbiotic bacteria, and the fact that both HWA and the balsam woolly adelgid (*A. piceae*) fluoresce under UV light when attacked by a variety of predators.

The goals of the Alliance for Saving Threatened Forests are to understand the biological bases for resistance (mechanisms and genetic control), screen and breed fir and hemlock for adelgid resistance,

deploy resistant firs and hemlocks to restore natural stands and aid the Christmas tree and landscape industries. Strategies being pursued include searching for resistance within native populations, a long-term hybridization /backcrossing program, and biotechnology.

GRADUATE STUDENT PRESENTATIONS

GRADUATE STUDENT SESSION 1
Brytten Steed moderator

Resource allocation, primary sex ratios and mortality in mountain pine beetles

Leanna Lachowsky[1] and Mary Reid[1]
[1]University of Calgary

Natural selection favours equal sex ratios, yet mountain pine beetles, *Dendroctonus ponderosae*, typically have female biased adult populations (emerging offspring ca. 2:1 F:M). This female bias is usually attributed to differential male mortality, but this has not been formally tested. Differential resource allocation could affect the primary (brood) sex ratio or could affect survival during development leading to a biased secondary sex ratio, which may have implications for population dynamics.

If female insects in better condition produce larger offspring, they should invest more in daughters. We varied maternal condition of MPB, *Dendroctonus ponderosae,* and found that larger females in better condition laid larger and more numerous eggs, but egg size did not differ between sons and daughters. When controlling for maternal condition and size, a tradeoff was observed between the size and number of eggs produced. Average egg size increased with laying order, indicating that mothers may be able to improve their condition as they build their gallery.

Primary brood sex ratios varied from male to female biased, but over all broods the average sex ratio and proportion invested in each sex was equal. Hatch success was high under artificial conditions and there was no difference in density of offspring between the egg and larval stages. However, significant mortality occurred during the larval and pupal stages. In broods with greater mortality the resulting adult sex ratio was more female biased, thus supporting the idea that males are disadvantaged during development and experience higher mortality.

The impact of mountain pine beetle on foliar moisture and surface fuels in whitebark pine stands in Wyoming and Montana

Chelsea Toone and Michael Jenkins
Utah State University

Mountain pine beetle (*Dendroctonus ponderosae* Hopkins, MPB) has caused extensive mortality in whitebark pine (*Pinus albicalus* Engelm, WBP) forests. Previous studies have been executed in lodgepole pine, Douglas-fir, and Engelmann spruce stands examining bark beetle, fuels, and fire interaction. These studies have shown that litter, duff, and 1 hour (< 0.64 cm diameter) and 10 hour (.64 cm>2.54cm diameter) fuels are the most influential in fire behavior. These studies also show that as a result these fine fuels are most significantly increased during an outbreak. Beetle killed stands also open the canopy creating a higher mid-flame wind speed, drier fuels, and a lower probability for active crown fire. They also increase temperature and lower surface foliar moisture content.

The object of the study was to measure fine fuels directly beneath WBP; both pre- and post-MPB outbreaks. The pine fuel zone is the area directly beneath conifer trees where fine fuels accumulate. In June of 2012 a fire in south central Utah burned fuels beneath pinyon pine causing a "shadow" effect, leaving a darkened area beneath trees. Data for this study was specifically collected beneath different crown classes in the pine fuel zone caused by MPB; green (healthy), red (two years since initial MPB attack with 50% or greater remaining) and gray (greater than two years since attack with between 15% and 45% needles remaining). Foliar moisture content was also measured in four different crown classes caused by MPB; green, green infested (current attack), yellow (last year attack) and red.

Foliar moisture data was collected in Wyoming using traditional methods. Surface fuels data was collected in Wyoming and Montana using a modified method of fuels data collection. Litter, duff, 1 hour and 10 hour fuels were measured under individual trees. Trees were selected in plots along transects five chains apart. Results from this study showed that foliar moisture content changed dramatically between the green infested stage to the yellow stage. Litter and duff depths increased as tree crowns changed from green, to red, to gray. 1 hour and 10 hour fuels also increased from green to red, but red and gray did not show a significant increase.

What mountain pine beetles could learn from tree acoustic emissions

Mathias Kaiser[1] and Mary Reid[1]
[1]University of Calgary

As moisture stress increases in plants, the tension in their water conducts increases. If the tension in a xylem cell becomes too high, air embolism can occur in an event called cavitation. A cavitated cell is no longer contributing to water transport, reducing a plant's ability to photosynthesize and assimilate carbon. Each cavitation also produces an acoustic emission (AE) and the rate of AEs was shown to be a good indicator of moisture stress for many plants, including several species of coniferous trees. Previous work suggested that AEs may be a source of information about the quality of potential hosts for herbivorous insects.

The mountain pine beetle (*Dendroctonus ponderosae*, MPB) is a species of bark beetles that uses different acoustic signals in a variety of contexts, suggesting the ability to detect differences in acoustic signals. As is exceptional for bark beetles, MPBs colonise living trees and need to overcome resinous tree defences. The main host of MPB, lodgepole pine (*Pinus contorta*), is one of the dominant tree species in western forests, but no previous work exists on acoustic emissions in this species. In this study we tested whether acoustic emissions in the frequency range of MPB signals are indicative of water stress in lodgepole pine. We further investigated whether emission rates of lodgepole pine contain information about individual tree quality and constitutive defences that could be useful for colonizing MPBs.

We obtained estimates of acoustic emission rates for 108 lodgepole pine trees in three stands around the Barrier Lake field station in Kananaskis, AB. Sampling occurred in mid-July and mid-August 2012 with an acoustic emission sensor (Type D9241A) that was chosen to be sensitive in the frequency range of MPB signals. We found that emission rate increased seasonally and diurnally. Average emission rate was higher in August than in July, indicating higher levels of moisture stress later in the summer. We also found a significant increase of emission rate with time in the afternoon, following peak photosynthetic activity of the trees around noon. Phloem thickness was inversely related to emission rate, which could be a useful cue for MPBs which seek lower or higher quality trees. Further analysis tested whether constitutive resin defence was predicted by emission rate but we did not find a significant relationship. Instead, the presence of constitutive defences was site-dependent and occurred more often in larger trees.

Our results suggest that lodgepole pine acoustic emissions are indicative of water stress, as in other coniferous species. They may further be used as a quality indicator by mountain pine beetles as phloem thickness was inversely related to emission rate. Constitutive resin defence was not predicted by acoustic emissions and future experiments should investigate their relationship with induced defences.

Effects of host constitutive alpha-pinene content on mountain pine beetle secondary attraction

Jordan L. Burke[1] and Allan L. Carroll[1]
[1]University of British Columbia

The current outbreak of mountain pine beetle (*Dendroctonus ponderosae*) has expanded north in latitude and up in elevation in recent years, and has expanded into novel habitats. These include lodgepole pine (*Pinus contorta*) forests in the northern region of British Columbia and Alberta in Canada, and recently into the jack pine (*Pinus banksiana*) forests and the hybrid zone in Alberta. Constitutive resin in these novel hosts contains elevated concentrations and proportions of alpha-pinene, which is the precursor to the aggregation pheromone *trans*-verbenol. In 2012 we conducted an experiment to investigate the relationship between constitutive alpha-pinene content and mountain pine beetle secondary attraction. Lodgepole, jack, and hybrid lodgepole/jack pine bolts were artificially infested with female mountain pine beetles and hung in an active infestation for 7 days. Bolts were then dissected and new attacks were counted. Hybrid pine bolts drew 75% of attacks, and contained significantly higher proportions of alpha-pinene. Attack patterns exhibited a strong exponential relationship with the proportion of alpha-pinene in the phloem.

GRADUATE STUDENT SESSION 2

Brytten Steed moderator

Physiological impacts to *Pinus ponderosa* following colonization of bark beetles and their associated fungi

Stephen J. Burr[1], Thomas E. Kolb[1], Richard W. Hofstetter[1] & Monica L. Gaylord[1]
[1]School of Forestry, Northern Arizona University, Flagstaff, AZ 86011, USA

Tree-killing bark beetle species are having major impacts on forest ecosystems in North America. The impacts of several species have surpassed documented past outbreaks. The exact mechanisms by which bark beetles overcome tree defenses and the physiological effects on host trees of bark beetle attack are still unknown. The role of symbiotic fungi in bark beetle colonization is widely debated. The close association of tree-killing beetles and associated fungi, and the nutrient poor substrate, in which beetles reproduce and develop, has led to speculation that fungi may be more a nutritional component for reproductive success than an ally in mass attacks of host trees. A comprehensive, systematic study documenting the temporal change in tree physiology post fungal inoculation will elucidate the role of fungi in bark beetle attacks on trees.

Historically, fungal associates of bark beetles were believed to be essential for the successful colonization of host species. Two main hypotheses address mechanisms by which fungal symbiants aid beetles in colonization: the first suggests that pathogenic fungi penetrate and occlude tree sapwood causing hydraulic failure culminating in the death of the host; the second proposes tree defense depletion, whereby the introduction of bark beetle fungi triggers an induced defensive response in host trees, indirectly leading to tree mortality by exhausting tree defenses more rapidly than beetle activity alone. Both hypotheses hold tree death as a requirement for beetle establishment. A third hypothesis, postulates fungus is not required to overcome a tree’s defenses, but rather provides a nutrient supplement following colonization allowing beetles to live and develop in an otherwise nutrient poor substrate.

This study will examine the impact of bark beetle symbiotic fungi on tree physiology and mortality. Additionally, I will use a stress treatment to assess the effect of tree stress on beetle and fungal colonization. While there are multiple species of bark beetles in Arizona, this region has had limited mortality of *Pinus ponderosa* from beetle attack. The resilient nature of the system will provide a rigorous test for beetles and their fungal associates to determine if they can adversely impact physiological processes in trees. Test trees will be separated into two groups: 1) a stressed group (trees will be stressed via root trenching) and 2) a non-stressed group, where trees are not root trenched. Trees in both groups will be challenged with three treatments: 1) bark beetles and their associated fungi (B+/F+), 2) bark beetle fungi alone (B-/F+), and 3) control trees, where both beetles and fungi are excluded (B-/F-). The primary goals of my study are to determine what physiological changes (i.e. decline in sapflow, water potential, resin production, etc.) and the rate they occur in *P. ponderosa* after treatments, and the effect of stress on beetle/fungi colonization. This study will provide insight into the impact of beetle fungal associates on tree physiology, their role in beetle colonization, and increase our understanding of the potential effect of tree stress on bark beetle/fungal/tree interactions.

Stand response to western spruce budworm defoliation and mortality in northern New Mexico, USA

Adam Polinko[1], Kristen Waring[1]
[1]School of Forestry, Northern Arizona University, Flagstaff, AZ

Western spruce budworm (*Choristoneura occidentalis* Freeman) is the most destructive native defoliator in the western United States. Populations of spruce budworm have been recorded at elevated levels in northern New Mexico since the early 1990's; the implications of the current outbreak on forest stand composition, structure and growth is unknown. Our research is investigating the influence of western spruce budworm on stand dynamics in northern New Mexico's dry mixed conifer and lower spruce-fir forest types. Specifically, the goals of this study are to: 1. determine whether the current western spruce budworm outbreak in New Mexico has affected overall tree species composition; 2. investigate the impact of the current western spruce budworm outbreak on tree regeneration; and 3. determine tree growth response to the western spruce budworm outbreak in surviving host and non-host trees.

We are selecting stands using United States Forest Service Forest Health Protection aerial survey data using years of detected defoliation as a predictor of stand-level defoliation and mortality and establishing a randomized, systematic grid of ten clusters of two, 0.02 ha plots in each stand. On each plot, we are recording overstory tree data, including species, diameter, height, and status (live or dead). For host trees, we are also recording level of defoliation. Understory trees are recorded in nested, 0.001 ha plots. Increment cores taken from a subset of overstory trees on each plot will be utilized for diameter growth comparisons. Historical stand exam data will be used to model stand conditions in the absence of an outbreak.

In the mixed conifer forest type, we hypothesize that species composition is shifting towards non-host species, which tend to be more fire- and drought-tolerant and may result in more resilient stands. In the spruce-fir forest type, a lack of non-host species may result in forest type conversions following prolonged defoliation and high levels of mortality.

Quantifying arthropod diversity in the Selkirk Mountains of northern Idaho and eastern Washington

Laine Smith[1], Stephen Cook[1], Michael Lucid[2] and Sam Cushman[3]
[1] Department of plant, Soil and Entomological Sciences, University of Idaho, Moscow, ID
[2] Idaho Department of Fish and Game, Coeur d'Alene, ID
[3] USDA-Forest Service, Rocky Mountain Research Station, Flagstaff, AZ

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.

CONCURRENT WORKSHOPS

BARK BEEETLE SYMBIOSIS
Haydeé Peralta moderator

It takes two (or more) to tango: Influence of phoretic mites on bark beetle-fungal relations

Richard Hofstetter[1] and John Moser[2]
[1] School of Forestry, Northern Arizona University, Flagstaff, AZ
[2] USDA Forest Service, Southern Research Station, Pineville, LA

Trees attacked and colonized by bark beetles are home to a variety of mites that comprise of fungivores, herbivores, scavengers, and predators. These mites can have important effects on the evolution and ecology of bark beetles and their associated fungi. For instance, mycetophagous mite species are capable of altering the frequency of bark beetle-mutualistic fungi or the abundance of antagonistic fungi that can drastically affect bark beetle behavior and population growth. We discuss how mites can promote or reduce insect-mutualistic fungi via processes that influence fungal transmission, reproduction, and growth. Alternatively, mites can disrupt insect-fungal associations through processes such as exploitative/interference competition, predation, or the promotion of antagonistic fungi. These processes influence ecological and evolutionary patterns of these communities in so far that mites can drive the pathogenicity and virulence of fungi in bark beetle-tree systems. We discuss the role of mites in the transmission of pathogenic, virulent fungi in systems such as Dutch Elm Disease, Hickory Decline, Thousands Canker Disease, southern pine beetle, and mountain pine beetle. We show that mites have the potential to alter interactions between species and the structure, diversity, and ecology of these communities.

Sometimes it takes more than two to tango: Spruce beetle multi-partite symbioses

Yasmin J. Cardoza[1], John C. Moser[2], Kier Klepzig[3] and Kenneth F. Raffa[4]
[1] Department of Entomology, NC State University, Raleigh, NC
[2] USDA Forest Service, Southern Research Station, Pineville, LA
[3] USDA Forest Service, Asheville, NC
[4] Department of Entomology, University of Wisconsin, Madison, WI

The spruce beetle, *Dendroctonus rufipennis*, has symbiotic associations with a number of microorganisms, including fungi, bacteria, mites and nematodes. Its most predominant fungal associate is the fungus *Leptographium abietinum*, a species of blue stain fungi (Ophiostomatales). Eight mite species are also associated with spruce beetles. In addition, seventy five percent of beetles examined carried nematodes, with six species in as many genera represented. One of the mite species, *Histiogaster arborsignis*, and one nematode species, *Bursaphelenchus rufipennis* n. sp. showed preference and performed well on *L. abietinum* cultures under laboratory conditions. It appears then that *L. abietinum* plays an important role in *D. rufipennis*' gallery communities involving phoretic mites and nematodes. These data add to our understanding of bark beetle symbiotic interactions; however, the nature of these multi-player symbioses remains to be clearly discerned.

Tango, Square Dance or Rave: Organismal Interactions at Bark Beetle Transformed Habitat

Jesse Pfammatter and Kenneth Raffa

By killing trees, bark beetles serve as ecological engineers and provide access for a highly diverse range of vectored organisms to previously inaccessible tree nutrients and habitat. This diverse assemblage includes bacteria, fungi, nematodes and mites. Interactions between species in this beetle-generated microcosm are often studied in pairs or small groups. However, in forest ecosystems, complex interaction webs often drive these communities. We begin with a description of the phoretic mite community on *Ips pini* in Wisconsin, including sources of spatial and temporal variation. We expand this survey to characterize the major mite feeding guilds, and describe substantial niche overlap in phoresy across diverse groups of bark beetle species and other subcortical insects. We then consider potential effects of mites on beetle reproductive success, and what tree and beetle cues mites may exploit to elicit detachment and reattachment behaviors. We present data ranging from pairwise to complex community web interactions surrounding this bark beetle transformed habitat.

INSECTS AND PATHOGENS IN WHITEBARK PINE
Steve Cook moderator

Whitebark Pine after Mountain Pine Beetle Outbreaks: Current Conditions and Regeneration

Kendra G. Schotzko and Stephen P. Cook
University of Idaho, Moscow, ID

Whitebark pine (*Pinus albicaulis*) has a large natural range but is declining in the Intermountain West due to a combination of white pine blister rust (*Cronartium ribicola*), forest succession, and recent outbreaks of mountain pine beetle (*Dendroctonus ponderosae*). Our project aims to obtain information that will be used to make recommendations and set priorities regarding restoration of whitebark pine in central Idaho and adjacent areas in Wyoming and Montana. Areas where recent mountain pine beetle outbreaks have occurred were identified and sampled using variable radius plots for mature trees and fixed area plots for regeneration. Data collected included tree species, diameter at breast height, and various condition factors. During our first field season we visited 22 sites in mountain pine beetle affected areas and assessed the abundance and condition of mature trees and regeneration. We found substantial mortality of mature whitebark pine at the majority of sites measured, largely due to mountain pine beetle. We also found a decrease in whitebark pine regeneration relative to subalpine fir (*Abies lasiocarpa*) at most of the sites.

Blister Rust and Small Whitebark Pine – Can They Co-exist?

John Schwandt, PhD.
Forest Health Protection, Coeur d'Alene, Idaho

The dramatic decline of whitebark pine (WB) populations across its range has been well documented. Many factors have contributed to this decline but the primary causes are mountain pine beetle (MPB) outbreaks killing mature trees, and white pine blister rust (WPBR) killing smaller trees and the cone-bearing tops of large trees. Results from three monitoring projects were presented.

Regeneration in MPB impacted stands: During 2008—2009, the severity of MPB impacts was measured in 42 whitebark pine stands in Idaho, Montana, and Wyoming. WPBR was recorded on remaining live, mature whitebark pine and whitebark pine regeneration. Probable stand trajectories were determined by comparing abundance and health of remaining whitebark pine with other competing tree species.

WPBR infection levels on remaining live, mature whitebark pine averaged 64% in northern Idaho, western Montana, and the Greater Yellowstone Area (GYA) (southwestern Montana, eastern Idaho, and northwest Wyoming) but only 4% in drier central Idaho. The condition of small WB were tallied on 26 of the 42 sites; the average infection level was 23%, but ranged from 0% to over 80%. The lowest average rust infection levels were in central Idaho (0 to 5.3%). Infection levels of regeneration in northern Idaho varied from 15% to 23%, those in western Montana ranged from 6.1% to 67.9%, and those in the GYA varied from 4.2% to 80.8%.

Regeneration of other species, primarily subalpine fir (*Abieslasiocarpa*), outnumbered whitebark pine in 69% of the areas. Based on WPBR and MPB impacts on whitebark pine and abundance of other tree species, at least 57% of sites surveyed will likely convert from whitebark pine to other cover types without restoration efforts or wildfire.

Additional stands in the Sawtooth area will be surveyed in 2012-13 and will be compared with results from these stands.

Blister rust in small Daylighted WB: The removal of competing vegetation from around WB ("daylighting") is being implemented to increase the vigor and survival of WB, and possibly reduce MPB attack success. Forest Health Protection is currently providing some funding for daylighting activities, and the Rocky Mtn Research Station is currently monitoring some daylighting treatments to document possible effects. In one of these areas where daylighting was used to release small understory trees, twenty trees were cut to determine the age of the understory. The average age of ten trees between 2.8 and 4.4 feet tall was 33.8 years while the average age of trees 10-12 feet tall was 83.7 years. More than half of the small WB were infected with blister rust.

<u>WPBR impacts on young, natural WB in northern Idaho:</u> In 1995, monitoring plots were established in five northern Idaho stands with natural WB regeneration. Plots were remeasured in 2001, 2007, and 2012 to document survival and condition of whitebark pine and competing vegetation. WPBR infection and mortality is increasing in all five areas.

NEW DIRECTIONS IN BARK BEETLE PHEROMONE RESEACH AND DEVELOPMENT
Darrell Ross moderator

New Insights into Bark Beetle Host Chemoreception

David Wakarchuk
Synergy Semiochemicals Corp.

Conifer infesting bark beetle host recognition relies on detection of about a dozen common monoterpenes. Proper host selection requires beetles not only recognize individual monoterpenes but also the ratio between them. The oxidation state of the monoterpenes is another recognition factor which provides cues regarding the health and vigour of the host.

Host monoterpenes are part of the tree defense system and are toxic to beetles colonizing the tree. Beetles exposed to these compounds metabolise the terpenes as part of detoxification processes. The oxidation of host terpenes by the beetles converts primary attractants to highly active secondary attractant semiochemicals. Further oxidation of the secondary attractants converts attractants into repellants or anti-aggregation compounds. For example, alpha-pinene, a primary attractant for Dendroctonus beetles becomes even more attractive when oxidized to cis or trans-verbenol. Finally when verbenols are oxidized to verbenone the attractant nature is replaced by repellant properties.

Historically bark beetle semiochemicals have been identified via dissection and extraction of the insect gut or by trapping volatiles released from insects or their hosts. Both of these methods require considerable micro-chemical skills and often these methods are hampered by lack of materials. With the limitations of these methods it is easy to miss semiochemicals that are present at very low levels.

At Synergy we have discovered a novel means of identifying new host recognition semiochemicals. From seven common monoterpenes we have prepared a library of several hundred oxidized monoterpenes which mimic cytochrome metabolic products. Using coupled gas chromatography-electroantennograph detection (GC-EAD) with three species of Dendroctonus, we have found that bark beetles recognize about one third of the library compounds. The compounds fall into three classes: compounds of known structure and biological activity, compounds of known structure and unknown biological activity and new compounds with unknown structures and biological activity. The activity of novel compounds have been characterised with trap challenge assays. Several new inhibitors have been identified for mountain pine beetle and for Douglas-fir beetle.

The desire to get close…but not too close: the multifunctional semiochemicals of bark beetles

Brian T. Sullivan
USFS Southern Research Station, Pineville, LA

It has been recognized for almost 40 years that certain bark beetle semiochemicals are "multifunctional", that is, they have attractant or attractant synergist effects at low release rates but inhibitory effects at high ones. Since the average airborne concentration of semiochemicals decreases with distance from the source, one might predict a similar reversal in the behavioral effect of multifunctional semiochemicals depending on the distance of a target (such as a trap or tree) from the release point of the semiochemical. That is, multifunctional semiochemicals released at a rate sufficient to inhibit attraction to the point of release should enhance attraction to the surrounding area where the average semiochemical concentration is lower. The predicted spatial effect of such a semiochemical—creation of a "ring" of heightened attractiveness around a point of release to which attraction is reduced or eliminated—has received relatively little attention, despite the potential consequences for experimentation with / practical application of such semiochemicals and interpretation of their ecological function. I have been studying spatial and dose effects for *endo*-brevicomin, which is a multifunctional pheromone component produced by male southern pine beetles, *Dendroctonus frontalis* Zimmermann (SPB). *endo*-Brevicomin alters response of both sexes of SPB to sources emitting the attractive combination of the female pheromone component frontalin and host odors (i.e., pine resin monoterpenes; in experiments, turpentine or *alpha*-pinene). In traps baited with the latter 2-component attractant, *endo*-brevicomin releasers can either reduce (high release rate) or enhance (low release rate) beetle catches when placed directly on the trap, but they can enhance catches across a range of doses when displaced 4-32 meters away. Enhancement can be dramatic—10-50 fold increases in mean catches—whereas inhibitory effects can reduce catches by 70%. Thus relatively high release rates of *endo*-brevicomin result in a ring of attraction enhancement around its point of release, as predicted for a multifunctional semiochemical.

Based upon a simple model of the space/dose dynamic of multifunctional semiochemicals, it is possible to make certain predictions regarding beetle responses to artificial lures. One such prediction is that addition of a single dose of multifunctional semiochemical to a point source of attractant may simultaneously (1) increase the numbers of insects attracted to the source in the absence of other, nearby sources of the multifunctional semiochemical but (2) reduce attraction in the presence of such sources (e.g., a preexisting "background" of the semiochemical). This reversal was demonstrated for *endo*-brevicomin in the field in trapping tests with SPB. We hypothesize that this effect may explain the apparent reversal of *endo*-brevicomin activity (at a single dose) from attractant synergist to inhibitor when deployed either outside or inside active SPB infestations, respectively. The spatial behavior of multifunctional semiochemicals should allow them to function simultaneously as cues for an appropriate habitat but an inappropriate landing/attack site. In the case of *endo*-brevicomin and SPB, the pheromone component may enhance the ability of beetles to locate isolated, infested trees or infestations while avoiding fully-colonized trees within infestations.

Bark beetle pheromone research to support technology development

Darrell Ross
Oregon State University, Corvallis, Oregon

Bark beetle pheromone research and technology development have been active areas of study since the 1970's when the first bark beetle pheromones were identified. Historically, the USDA Forest Service provides the majority of support for these activities in the US. Recent trends suggest severely declining support for research and smaller reductions in support for technology development. The declining support for research needs to be reversed to increase the likelihood of successful technology development efforts in the future. Without a strong research basis, technology development projects will face decreasing chances of success, which in turn will likely threaten the continued funding for technology development. Furthermore, attempts to implement poorly developed pheromone-based management strategies will undermine natural resource manager's confidence in using these types of tools. More research should be focused on the basic biology and ecology of bark beetle pheromone systems, for example, changes in beetle response to pheromones at different population densities. Examples of successful and unsuccessful efforts to develop pheromone-based strategies are presented to emphasize the need for stronger commitments to basic research projects.

SPATIAL ANALYSIS OF FOREST INSECTS

Jeff Hicke moderator

Modeling the spread of mountain pine beetle with space-time dependent environmental predictions

Zachary A. Holden[1], Erin L. Landguth[2], Jordan Purdy[3]
[1]USDA Forest Service Northern Region, Missoula, MT
[2]University of Montana Department of Biology, Missoula, MT
[3]Augustana College Department of Mathematics, Rock Island, IL

Mountain pine beetle (MPB) spread occurs at fine spatial and temporal scales and accurately forecasting potential spread will require finely resolved spatial predictors, and models that account for spatio-temporal interactions between climatic and host species controls on MPB-induced tree mortality. We applied a novel space-time dependent logistic regression model to predict beetle spread across the Helena National Forest, Montana, where a massive outbreak occurred over the last decade. We first mapped the spread of mountain pine beetle-induced mortality from 2000-2009 using time series of MODIS satellite imagery. We validated detection using 274 field plots with repeated measurements with on overall accuracy of 78%. As spatial predictors, we developed high resolution (60m) habitat suitability models for all potential host tree species using Forest Inventory and Analysis (FIA) plots with climatic water balance models as predictors. Additional spatial and temporal predictors included estimates of tree size class, monthly temperature, and a very high resolution climatic water balance model that incorporates the influences of wind speed and insolation on moisture deficits. Our preliminary results suggests that interactions between climate and host tree size and vigor mediate the temporal and spatial dynamics of

beetle activity. The results and methods used in this study are being incorporated into TOPOFIRE, a web-based interactive server for mapping insect and climate-induced influences on fuel moisture and fire danger in complex terrain.

Slow down, bring your friends, and eat a tree: How phenology and differential dispersal predict landscape patterns of mountain pine beetle impact

James A. Powell[1] and Barbara J. Bentz[2]
[1] Utah State University, Logan, UT
[2]USDA Forest Service Rocky Mountain Research Station, Logan, Utah

The mountain pine beetle (MPB, *Dendroctonus ponderosae* Hopkins), is an aggressive insect which attacks living host trees (of genus *Pinus*). Pines have significant defensive mechanisms, requiring the beetles to attack *en masse* to successfully colonize. Temperatures directly but nonlinearly influence the rates at which insects complete development in their various life stages and therefore the timing (phenology) of their emergence. Since the beetle larvae consume the phloem underneath the bark each year they exhaust their host, requiring dispersal to new trees. Adult beetles must colonize during a relatively narrow window of time to take advantage of warm temperatures for oviposition, but must also attack late enough to make sure that cold-hardened larvae appear during winter. Thus the beetles exist in a precarious niche depending on carefully synchronized timing and dispersal. Changing temperatures have broadened that niche across vastly larger regions, leading to tree mortality across more than thirty million hectares of western North America. Impacts due to MPB have been larger than fire, challenging researchers to predict risk factors and rates of population growth. However, statistical models fit to data at a variety of scales have failed to describe MPB outbreaks in anything more than probabilistic terms.

We have developed a mechanistic approach based on: differential beetle motility between forested and unforested habitats (landscape resistance), phloem temperature control of MPB phenology, and the Allee effect resulting from the need to mass-attack new hosts. The resulting partial differential model describes MPB aggregation at scales commensurate with changes in host density. Solutions are complicated and discontinuous, but homogenization results in a surprisingly simple diffusive approach suitable for rapid integration over watersheds and regions and able to accommodate forest demographics resolved on 30m scales. In fact, with a speed-up of over six orders of magnitude, it is feasible to calibrate the model using Markov Chain Monte Carlo (MCMC) procedures and Aerial Damage Survey (ADS) data from central Idaho. We determine a distribution of motility and demographic parameters in a Bayesian framework, and validate the model by comparison with ADS data collected in the eastern Cascades. This description of MPB behavior captures patterns of observed tree mortality as well as details of demographic growth rates.

Characterizing spatial and temporal patterns of mountain pine beetle-caused tree mortality using Landsat imagery

Arjan J. H. Meddens and Jeffrey A. Hicke
University of Idaho, Moscow ID

Mountain pine beetles (*Dendroctonus ponderosae* Hopkins) cause significant tree mortality in coniferous forests across North America. Mapping beetle-caused tree mortality is therefore important for assessing trends and impacts to forest ecosystems. Remote sensing offers the potential for accurate, repeatable estimates of tree mortality in outbreak areas. We quantified the amount of tree mortality within a pixel by applying a disturbance detection method to multi-temporal Landsat data. A fine-resolution classified image based on aerial imagery was used as reference data for model building and evaluation of a continuous measure of bark beetle-caused tree mortality. The final model explained >75% of the variance using three Landsat spectral variables. We present spatial and temporal characteristics of the tree mortality caused by the mountain pine beetle outbreak within the north-central Colorado study area. The bark beetle-caused tree mortality within the Landsat scene showed rapid spread across the study area. Substantial tree mortality was initially detected in 2001 and by 2011 approximately 20% of the forest within the Landsat scene was comprised of trees killed by the beetle. The outcomes of this study will increase understanding of the temporal characteristics of tree mortality at different spatial scales, and help inform subsequent studies assessing impacts on forest fuels, hydrology, and biogeochemical cycles (e.g., the carbon cycle).

BASIC ECOLOGICAL APPROCHES TO UNDERSTANDING BARK BEETLES
Diana Six moderator

Estimating surface and canopy fuel conditions after mountain pine beetle outbreaks in northern Rocky Mountain ecosystems

Robert Keane and Brian Izbicki
USDA Forest Service, Rocky Mountain Research Station, Missoula Fire Sciences Laboratory, Missoula, MT

It is generally assumed that insect and disease epidemics, such as those caused by the mountain pine beetle, predispose damaged forests to high fire danger by creating highly flammable fuel conditions. While this may certainly be true in some forests, these dangerous fuel conditions many only occur for a short time when evaluated at a landscape level. Others feel these epidemics may cause high surface fuel loadings when the dead material from dead trees falls to the ground thereby facilitating abnormally severe fires. This presentation will discuss a study that measured, through intensive field collections, the effect that exogenous disturbance events, namely mountain pine beetles, have on future fire hazard and risk. Surface fuel loadings and deposition rates were annually measured for several lodgepole pine forests after beetle epidemics to quantify describe fuel dynamics to ultimately estimate resultant fire behavior in heavy mortality stands. Fuel deposition was measured using semi-annual collections of fallen biomass sorted into six fuel components (fallen foliage, twigs, branches, large branches, logs, and all other material). Surface fuel loadings were measured using planar intercept and ocular techniques. Canopy fuels were estimated from measured tree population surveys and allometric equations. We found that most of the needles from dead trees were deposited over 3-5 years, and this foliar material quickly decomposed creating little changes in litter fuels. We also found that fine woody debris falls at low rates and therefore did not significantly change fuelbed properties until the tree actually fell after 10-15 years. The findings of this study illustrate that increases in fire hazard are short lived, and usually the fire hazard of beetle-killed stands decline quickly for a decade.

The influence of bark beetle infestation on fuel loadings and fire behavior in southwestern ponderosa pine

Matt Hansen[1], Barbara Bentz[1], Jim Vandygriff[1], Steve Munson[2], Joel McMillin[3]
[1]Rocky Mountain Research Station, Logan, UT
[2]Forest Health Protection, Ogden, UT
[3]Forest Health Protection, Flagstaff, AZ

During the mid-1990s, permanent plots were established in southwestern-type ponderosa pine to gather data for parameterizing a bark beetle susceptibility model. There are ~45 sites in southern Utah, northern Arizona, and southwestern Colorado, each with twenty 0.1 acre plots. Most sites were visited every 3-5 years, including during 2012, and we have a nearly 20 year record of bark beetle-caused tree mortality. During the most recent re-measurements, we added line transect sampling, based on FIREMON protocols, to determine fuel loadings as a function of infestation levels. Preliminary results indicate a significant positive relationship between infested basal area and biomass of downed woody materials >0.5" diameter. Biomasses of litter, duff, and downed woody materials <0.5" diameter were not significantly related to infested basal area, possibly due to relatively rapid decomposition of these materials coupled with their reduced inputs in the years after beetle-caused tree mortality. Standing fuel loadings (live and dead) have not yet been quantified. We plan to use the Fire and Fuels Extension of the Forest Vegetation Simulator to examine fire behavior as a function of infestation levels, using that of uninfested plots as a reference.

Geographic variation in mountain pine beetle development and reproductive success: implications for spread into new habitats

Katherine P. Bleiker and Gregory D. Smith
Canadian Forest Service, Natural Resources Canada, Victoria, BC, Canada

Mountain pine beetle (MPB) *Dendroctonus ponderosae* Hopkins (Coleoptera: Curculionidae) has breached the geoclimatic barrier posed by the Rocky Mountains and invaded northern Alberta. Environmental and biological processes that drive MPB population dynamics may differ between the western coniferous forests of the beetle’s historic range in British Columbia and the recently-invaded boreal forest of northern Alberta. We examined beetle development and reproductive success for populations east and west of the Rocky Mountains for two generations of insects. Preliminary results from fieldwork indicate that insects developing in northern Alberta were more likely to enter the winters of 2010/11 and 2011/12 as late instar larvae, the most cold hardy stage, compared to insects developing at sites in north-western or southern British Columbia, which were more likely to enter the winter as early instar larvae or eggs. In the two generations sampled, beetle productivity and insect size were generally higher, and the sex ratio of emerging beetles was usually closer to one, at sites in northern Alberta than at

sites west of the Divide in British Columbia. Implications for outbreaks and continued spread east of the Rocky Mountains in Canada are discussed.

Condition-dependent responses to tree quality by mountain pine beetles

Mary Reid
University of Calgary, Calgary, AB

Reproductive success and population dynamics of mountain pine beetles, *Dendroctonus ponderosae*, have long been linked to the state of trees, particularly phloem thickness and tree defenses. More recently, the importance of beetle state in determining colonization success and reproduction has been considered. Here I examine the interaction of the two: how do the effects of tree state depend on beetle state? Field observations revealed that females in better body condition were more likely to settle on larger trees with thick phloem, consistent with both greater choice and better ability to tolerate tree defenses. Fumigant toxicity studies revealed only females in good body condition could survive high concentrations (1250 ppm) of monoterpenes comparable to induced defenses. Sub-lethal effects of monoterpenes ($\leq$ 125 ppm) also depended on female body condition. Compared to female in poorer condition, females in better condition were more likely to increase egg size at the expense of egg number after exposure to moderate terpene concentrations (31 ppm). However, females in better condition overall tended to invest less in current reproduction after monoterpene exposure compared to controls, possibly to favor future reproduction in better conditions. Body condition also influenced the effects of tree growth rate on reproduction. Females in poor condition tended to have smaller and fewer eggs than did females in good condition across all growth rates, while females in good condition invested more in faster growing trees than in slower growing trees. Taken together, larger females in better condition may disproportionately contribute to population increases by being able to succeed in vigorous trees. The conditions that favor beetles and trees need to be jointly considered to predict outbreaks.

The effects of tree chemistry and beetle chemical legacy on growth of a fungal mutualist

Thomas "Seth" Davis[1] and Richard W. Hofstetter[1]
[1]Northern Arizona University, Flagstaff, AZ

We tested the hypothesis that chemical polymorphism in a plant population mediates the performance of nutritional microbial symbionts. We surveyed the composition of ponderosa pine resin in northern Arizona, USA, for variation in six monoterpenes, and we approximated four chemical phenotypes. We reared populations of an herbivorous tree-killing beetle (*Dendroctonus brevicomis*) in ponderosa pine host material, controlling for three monoterpene compositions representing an α-pinene to Δ-3-carene gradient. Beetles were reared in host material where the dominant monoterpene was α-pinene, Δ-3-carene, or a phenotype that was intermediate between the two. We isolated nutritional fungal symbionts (*Entomocorticium* sp. B) from beetle populations reared in each phenotype and performed reciprocal growth experiments in media amended to represent four "average" monoterpene compositions. This allowed us to test the effects of natal host phenotype, chemical polymorphism, and the interaction between natal host phenotype and chemical polymorphism on a nutritional symbiont. Three important

findings emerged: (1) fungal isolates grew 25–32% faster when acquired from beetles reared in the intermediate phenotype; (2) the mean growth rate of nutritional fungi varied up to 44% depending on which monoterpene composition media was amended with; and (3) fungal isolates uniformly performed best in the intermediate phenotype regardless of the chemical composition of their natal host. The performance of nutritional fungi related to both the chemical “history” of their associated herbivore and the chemical phenotypes they are exposed to. However, all fungal isolates appeared adapted to a common chemical phenotype. These experiments argue in favor of the hypothesis that chemical polymorphism in plant populations mediates growth of nutritional symbionts of herbivores. Intraspecific chemical polymorphism in plants contributes indirectly to the regulation of herbivore populations, and our experiments demonstrate that the ecological effects of plant secondary chemistry extend beyond the trophic scale of the herbivore–plant interaction.

The kids aren't alright: identifying the cause of hybrid male sterility in the mountain pine beetle

Ryan R. Bracewell
University of Montana, Missoula, MT

Hybrid male sterility is often the first reproductive incompatibility to form during speciation. Some mountain pine beetle (*Dendroctonus ponderosae*) populations show evidence of hybrid male sterility when crossed, suggestive of incipient speciation in this economically and ecologically important species. Crosses between a southern California population and populations throughout California and Oregon produce viable and fertile offspring, yet when the southern California population is crossed to an Idaho population, a strong bidirectional incompatibility results and ~95% of their sons are sterile. Crosses between the Oregon and Idaho population show a relatively weak unidirectional incompatibility, whereby a small proportion of sons from Idaho females are completely sterile, and the remaining males show a ~50% decrease in fecundity. In the present study, crosses between a population from northern California and western Montana were conducted to determine the strength of reproductive isolation in crosses of an intermediate geographic distance (with respect to the OR/ID boundary) and to explore the physiological mechanisms involved in the incompatibility. In these crosses a large percentage of hybrid males in one direction of the cross are sterile, while hybrid males in the reciprocal cross are fully fertile. Females crossed to sterile hybrid males show evidence of mating, yet have little to no sperm in their spermatheca. Sterile hybrid males have drastically reduced sperm production indicative of a breakdown during spermatogenesis. When combined with results from previous crossing experiments, these results suggest increasing levels of hybrid male sterility with distance from the OR/ID boundary. These findings highlight the role of geography in the evolution of reproductive incompatibilities and help identify the physiological mechanisms responsible for hybrid male sterility in the mountain pine beetle.

DEFOLIATOR MANAGEMENT AND BIOCONTROL
Tom Eckberg moderator

Egg Parasitoids and Viral Incidence in Douglas-Fir Tussock Moth Populations

Stephen Cook
University of Idaho, Moscow, ID 83844-2339
Department of Plant, Soil and Entomological Sciences

Douglas-fir tussock moth, *Orgyia pseudotsugata* (McDunnough), is a common defoliator of several tree species including Douglas-fir and true firs in the inner-mountain west. Outbreaks of the moth tend to be intense, but short in duration. Natural enemies are usually involved with outbreak collapse. Two of the mortality agents are the naturally occurring nuclear polyhedrosis virus that infects caterpillars and a complex of hymenopteran egg parasitoids that includes a scelionid, *Telenomis californicus* Ashmead, a trichogrammitid, *Trichogramma minutum* Riley, and a eulophid, *Tetrastichus* sp. During the last two outbreaks in northern Idaho, we have investigated potential impacts on parasitoid presence and abundance of various management practices including the application of the moth's male attractant pheromone in mating disruption trials and the presence of the parasitoid community during a viral epizootic.

During 2001, the male attractant pheromone (Z-6-neneciosen-11-one) was applied at two treatment doses during the last summer of a DFTM outbreak in northern Idaho. The most abundant parasitoid reared from the egg masses during this study was *T. californicus*. There was a significant reduction in egg mass density that was related to pheromone dose. There was no significant overall relationship between pheromone dose and parasitoid production per egg mass. However, there was a significantly higher ratio of parasitoids per larva when fall-collected egg masses from pheromone-treated plots were compared to the controls. This relationship was no longer present in the spring-collected egg masses.

During this past year (winter of 2011-spring 2012), we examined viral incidence and egg parasitoid emergence from egg masses as well as the overall mortality caused by each agent. Viral-caused mortality of caterpillars ranged from 0-45% for populations collected from 23 locations. Viral-caused mortality was recorded at 17 of the 23. Parasitoids emerged from egg masses collected at 21 of the 23 sites. Again, the most abundant parasitoid reared from the egg masses was *T. californicus*. Parasitoid recovery was low, but the number of parasitoids recovered during this study is probably a conservative estimate because egg masses were only collected during the fall, before the parasitoids would have completed ovipositing in the field. Total larval mortality was significantly correlated with viral-caused mortality but there was no significant relationship between viral-caused mortality and the proportion of eggs parasitized within an egg mass or the number of parasitoids emerging from an egg mass.

Acknowledgements: The USDA-Forest Service provided funding for the virus application-parasitoid study and the work was conducted in collaboration with John Wenz, Iral Ragenovich, Dick Reardon and Carol Randall. The Idaho Department of Lands provided funding for examining the incidence of virus and egg parasitoids in the 2011/12 egg masses and the work was conducted in collaboration with Tom Eckberg. Lindsay Menard, an undergraduate lab technician in my group, was involved with much of the rearing in my laboratory.

Spreading the Virus: What Have We Learned about Controlling Douglas-fir Tussock Moth?

Connie Mehmel

Douglas-fir tussock moth *(Orgyia pseudotsugata)* is a major defoliator of Douglas-fir and true firs. In 2010 the Methow Valley Ranger District in eastern Washington controlled portions of a building outbreak by aerially spraying infested sites with the biological insecticide TM-BioControl1, a naturally-occurring virus. The spray initiated a virus epizootic within 24 hours. However, a natural epizootic began in unsprayed areas 40 days later. The population collapsed in sprayed and unsprayed areas alike. Further study on conditions affecting epizootics is warranted.

Persistence of introduced parasitoid wasps used for biocontrol of larch casebearer in western larch forests

David Shaw[1], **Mailea Miller-Pierce[2]**, Ari DeMarco[2], and Paul Oester[3].
[1]Oregon State University, Corvallis, OR
[2]Washington State University, Vancouver, WA
[3]Oregon State University, La Grande, OR

We reared parasitoid wasps associated with the larch casebearer (*Coleophora laricella* (Hubner)), a non-native insect that continues to impact western larch (*Larix occidentalis* Nutt.). Impacts were historically mitigated through a biological control program that released 7 species of parasitoid wasps in the 1960's and 1970's. Of this group,*Agathis pumila* (Ratzeburg) (Hymenoptera: Braconidae) and *Chrysocharis laricinellae* (Ratzeburg) (Hymenoptera: Eulophidae).have been considered the only two species of introduced wasps that successfully established in *C. laricella* populations associated with western larch in the PNW. Our objective was to determine whether the introduced parasitoid wasps were still present in the populations of larch casebearer. We sampled 53 larch casebearer sites in Oregon (13), Washington (15), Idaho (10), and Montana (15) across the range of western larch in the USA. At each study site, 10 western larch trees (at a few sites it was not possible to get 10 trees) had four branch samples removed which were placed into a single rearing box in the field and transported to Corvallis,OR for rearing. Only two introduced parasitoid wasps were found in our samples; *A. pumila* and *C. laricinellae*. *A. pumila* was found at 43 sites (81% freq.) while *C. laricinellae* was found at 35 sites (66% freq.). Fifteen species of native parasitoid wasps were reared in these samples also.

New Rules: Defoliator Suppression Programs and the Clean Water Act-Idaho's 2012 Experience

Tom Eckberg
Idaho Department of Lands, Coeur d'Alene ID 83815

The forests of northern Idaho have experienced an outbreak of Douglas-fir tussock moth *Orgyia pseudotsugata* (McDunnough) approximately once per decade since the 1940s. The outbreaks usually cause visible defoliation for two to three years, and can cause growth loss, top kill or mortality of grand fir and Douglas-fir. The state of Idaho has a long history of treating these outbreaks to minimize impacts to the forest resource dating back to the first availability of effective insecticides and aerial application equipment in the 1940s. All insecticides must be applied in compliance with federal, state, and local regulations and guidelines. Recent litigation at the national level has resulted in a different interpretation of federal law as it relates to forest canopy pest control applications. Since October 2011, all suppression projects of defoliating insects in the United States have been subject to new regulations in order to comply with the Clean Water Act. These regulations will differ in scope depending on the state, the proximity to water, the presence of threatened or endangered species, and the size of the project. Most states have an internal agency that issues permits for the National Pollution Discharge Elimination System (NPDES); however Idaho is one of six states that use the United States Environmental Protection Agency as the NPDES permitting authority for the Clean Water Act. A small Douglas-fir tussock moth suppression project was conducted on private lands in northern Idaho in 2012 that was subject to these new rules. Due to the small size of the project, the absence of anadromous fish in the area and the fact that no state lands were treated, the overall impacts to the project were minimal.

BEYON THE NATIONAL I&D RISK MAP: CHARTING A COURSE FORWARD
Eric Smith moderator

This session summarized the procedures and results of the 2012 National Insect and Disease Risk Map and presented how the results and the component data layers can be used in future projects and analyses at national and regional scales. The session included a group discussion of opportunities and needs for integration with ongoing applications.

AMBROSIA BEETLES – THE 'NEW' BIG THREAT
Tim Paine moderator

AMBROSIA BEETLES SYSTEMATICS: NON-NATIVES IN THE US

Robert J. Rabaglia
USDA Forest Service, Forest Health Protection, 1621 N Kent St (RPE7), Arlington, VA 22209

Bark and ambrosia beetles (Coleoptera: Curculionidae: Scolytinae) are one of the most important groups of insects affecting forests and trees worldwide. There are approximately 560 species currently reported in the United States, and 62 of these are non-native species. Since the 1980's, the rate of introduction and detection of these non-native species has been steadily increasing. Of the 62 species, 28 are considered ambrosia beetles, most of which belong to the tribe xyleborini. These beetles are successful invaders because they are cryptic, have a skewed sex-ratio with a sib-mating system and have a broad host range. Although the majority of non-native scolytines established in the US are ambrosia beetles, they are often undetected in cargo. Among the top 30 genera intercepted in US ports, only four ambrosia beetle genera are represented.

All ambrosia beetles carry with them symbiotic fungi which serve as a food source. Several of the bark and ambrosia beetles that have had the greatest impact on North American forests are ambrosia beetles, such as the red bay ambrosia beetle, which vectors the laurel wilt fungus, or bark beetles, such as the European elm bark beetle, which vectors the Dutch elm disease fungus.

In Los Angeles County, California, a large number of box elder (*Acer negundo*) trees were found dying in 2010. By 2012, backyard avocado trees (*Persea americana*) were also found dying in the Los Angeles area. The beetles associated with these dying trees were identified as *Euwallacea fornicatus*, a non-native ambrosia beetle first reported in the continental US in 2002 in Florida and 2003 at Whittier Narrows, Los Angeles County. Also associated with this beetle in California was an undescribed species of fungus in the genus *Fusarium*. By the summer of 2012, the beetle and fungus were found associated with dying trees in Los Angeles and Orange Counties, California. In 2009, there were reports of similar symptoms and mortality of avocado trees in Israel. The same beetle and fungus were found associated with this mortality in Israel.

Although the beetles in both California and Israel were identified morphologically as *E. fornicatus*, commonly known as the tea shot-hole borer from southern Asia, large differences in DNA sequences between these beetles and those from tea in Sri Lanka and other parts of Asia, indicate that the beetles in California and Israel may be a different species. In addition, the *Fusarium* associate of the beetles in California and Israel is the same, but different from the *Fusarium* associated with beetles from other parts of its range.

Additional work is being conducted to identify the species found in California and Israel. It is still unclear if this is a new species, a cryptic sibling species or a species currently recognized as a synonym of *E. fornicatus*.

Impact of the polyphagous shot hole borer, *Euwallacea* sp., in the forests of southern California

Tom W. Coleman[1], Richard Stouthamer[2], and Akif Eskalen[3]
[1]USDA Forest Service, Forest Health Protection, San Bernardino, CA
[2]Department of Entomology, University of California, Riverside
[3]Department of Plant Pathology, University of California, Riverside

The Polyphagous shot hole borer, *Euwallacea* sp. (Coleoptera: Scolytinae), was first detected in 2003 in southern California, but not linked to tree injury and mortality until 2012. The Polyphagous shot hole borer was initially identified as the tea shot hole borer, *Euwallacea fornicatus*, but recent genetic work suggests it is separate species. The invasive ambrosia beetle has been found in three counties in southern California and is the same species found attacking avocados in Israel. The insect and disease complex has caused crown dieback and tree mortality of several tree species primarily in the urban areas of Los Angeles County. Currently, the ambrosia beetle is known to complete development in 24 hardwood species. The beetle prefers to attack box elder, castor bean, avocados, willows, coast live oak, and California sycamore. During ground surveys, the main stem and larger branches of hardwoods were observed for the presence of crown thinning, entry holes, boring dust, and any wound response. Two infestations of the polyphagous shot hole borer were detected on the Angeles National Forest, Los Angeles Ranger District. Red willow, castor bean, and white alder were severely injured by the insect and disease complex in this area. Eleven species of hardwoods are common across the national forests in southern California and susceptibility of all these native species to the insect and disease complex is not yet known. Forest Health Protection will collaborate with the University of California, Riverside to expand the detection efforts for the new insect and disease complex in 2013 on public and on private land in southern California.

Biology and control of *Euwallacea* sp., the new ambrosia beetle affecting California agriculture, urban, and riparian forest communities.

T. D. Paine, M. E. Jones, and C. C. Hanlon

A species of ambrosia beetle (Coleoptera: Curculionidae: Scolytinae), closely related to the Southeast Asian species, *Euwallacea fornicatus*, was first identified in Southern California in 2004 (Rabaglia et al. 2006). Since that time it has expanded its geographic range to include Los Angeles, Orange, and San Diego Counties. More critically for the avocado industry, it has expanded its host range to include a large number of tree species, including avocados, common landscape trees, native forest trees, and weedy invasive species. The large number of potential host trees could result in large populations of beetles in areas adjacent to commercial avocado production areas. The beetle is associated with a fungal complex including a *Fusarium* species that has caused extensive tree mortality.

The life history of ambrosia beetles is unique among the scolytinae bark beetles. Although the adult females construct oviposition galleries, the larvae do not eat wood. The beetles are associated with a number of ectosymbiotic fungi that are inoculated into the galleries by the females (Fernando 1959). Eggs are laid in niches, or cradles, along the adult galleries and the larvae that emerge from the eggs feed on the fungi that are inoculated into the niches by the ovipositing females. It is not clear whether the *Fusarium* species that has been associated with the beetles is part of the obligate symbiotic association or whether it is one of a number of ectosymbiotic fungi.

It is clear that there is a pressing need for more information for effective management of the insect/fungus complex. In the immediate term, it is necessary to provide short term tools for the industry to protect their trees. The range of options may include direct control using contact or systemic insecticides to prevent infestation or to kill infesting beetles to limit spread (Cranham 1966, Paine et al. 2011). It is also necessary to develop effective sanitation of infested wood to prevent emergence. This could include chipping or solarization. These approaches must be tested for efficacy.

The longer term solutions will involve understanding more about the life history and ecology of the pest complex in California. This will require understanding more about the environmental requirements, the reproductive biology, the susceptibility and suitability of commercial, wildland, and landscape hosts (e.g., Hanks et al. 1995, 2005), the attraction of host materials to the insects (e.g., Hanks et al. 1993, Paine et al. 2000), and the influence of host condition on beetle success (e.g., Hanks et al. 1999, Pane and Hanlon 2010).

References:

Cranham, J.E. 1966. Shot-hole borer (*Xyloborus fornicatus* Eichh) of tea in Ceylon. 1. Chemical control and population dynamics. Bulletin of Entomological Research 56:481.

Fernando, E.F.W. 1959. Storage and transmission of ambrosia fungus in the adult *Xyleborus fornicatus* Eich. (Coleoptera: Scolytidae) Ann. and Mag. Nat. Hist. 2:475-480.

Hanks, L.M., T.D. Paine, J.G. Millar. 2005. Influence of the larval environment on performance and adult body size of the wood-boring beetle *Phoracantha semipunctata* (F.) (Coleoptera: Cerambycidae). Entomologia Experimentalis et Applicata. 114:25-34.

Hanks, L. M., T. D.Paine, J. G. Millar, C. D. Campbell and Ursula K. Schuch. 1999. Water relations of host trees and resistance to the phloem-boring beetle *Phoracantha semipunctata* F. (Coleoptera :Cerambycidae). Oecologia. 119: 400-407.

Hanks, L. M., T. D. Paine, J. G. Millar, and J. L. Hom. 1995. Variation among *Eucalyptus* species in resistance to eucalyptus longhorned borer in Southern California. Entomologia Experimentalis et Applicata 74: 185-194.

Hanks, L. M., T. D. Paine, and J. G. Millar. 1993. Host species preference and larval performance in the wood-boring beetle *Phoracantha semipunctata* F. Oecologia (Berl.) 95: 22-29.

Paine, T. D., L. M. Hanks, J. G. Millar, and E. O. Paine. 2000. Attractiveness and suitability of host tree species for colonization and survival of *Phoracantha semipunctata* F. (Coleoptera: Cerambycidae). Canadian Entomologist 132: 907-914.

Paine, T. D., and C. C. Hanlon. 2010. Integration of tactics for management of *Eucalyptus* herbivores: influence of moisture and nitrogen fertilization on red gum lerp psyllid colonization. Entomologia Experimentalis et Applicata. 137:290-295.

Paine, T. D., C. C. Hanlon, and F. J. Byrne. 2011. Potential risks of systemic imidacloprid to parasitoid natural enemies of a cerambycid attacking *Eucalyptus*. Biological Control. 56:175-178.

Rabaglia Robert J.; Dole Stephanie A.; Cognat Anthony I. 2006. Review of American Xyloborina (Coleoptera: Curculionidae: Scolytinae) occurring noth of Mexico, with an illustrated key. Annals of the Entomological Society of America 99:1034-1056.

SKI AREA MANAGEMENT: FOREST HEALTH CHALLENGES AND OPPORTUNITIES

Nancy Sturdevant moderator

Management Challenges and Opportunities at Several Ski Areas in Montana

Nancy Sturdevant
USDA Forest Service, Forest Health Protection, Region One

Mountain pine beetle and western spruce budworm have been significantly impacting forest health and vegetation at most of the ski areas in Montana. Each ski area has unique set of challenges that require individual management plans. Each ski area also has various attributes that enable management to be accomplished at different levels and on different time frames. My presentation provides an overall view of these challenges and opportunities at each of four ski areas. Vegetation management plans are being developed or updated for each of the four ski areas primarily as a result of the impacts of bark beetles and budworm.

Colorado Ski Areas in Bark Beetle Country

Bob Cain and Tom Eager
Forest Health Protection, Rocky Mountain Region, Denver and Gunnison, Colorado

Ski tourism is a large component of the economy of state of Colorado. Most ski areas now function as year-round resorts, and are the focus of a wide range of support industries including large corporations and small businesses. Mountain pine beetle and spruce beetle epidemics have affected Colorado ski areas to varying degrees in the last decade. Differences in tree species diversity, management efforts and luck appear to have contributed to bark beetle effects on Winter Park Ski Area and Steamboat Ski Area in northern Colorado. In the southern portion of the state, increasing spruce beetle activity has begun to affect the appearance, values and operations on several ski areas. In general, the functioning of the biological system is at odds with the management of a for-profit entity. Forest Health Protection efforts have focused not only on dealing directly with tree mortality in these locales, but also on public education and integration of forest management activities with business driven processes.

Ski Area Conundrum: A case study of June Mountain Ski Area, Inyo National Forest, Mono County, California

Beverly M. Bulaon and Martin MacKenzie
USDA Forest Service, Forest Health Protection, Region 5

June Mountain Ski Area is a highly popular recreation destination located in the eastern Sierra Nevada range, Inyo National Forest, California (Region 5). Since 2005, the area has been experiencing a severe Mountain Pine Beetle outbreak particularly concentrated in the upper elevation whitebark pines, but recently moving south into dense lodgepole pine forests with no sign of abating. Management collaboration and cooperation between Forest, recreation permitees, and local communities have been on-going, but some basic factors and issues have made planning challenging. Severe declines in whitebark pines are occurring range-wide throughout western forests, that whitebark is considered for listing as an endangered species; however, options for conservation management are still largely experimental and effects unknown for California whitebark pines. As a ski area, public safety and potential continued use is a high priority issue that influences management choices for treatments. Additional concerns of economic impact, climate change, desired future conditions, and cost constraints all contribute to developing management strategies that further assist in improving health conditions for whitebark pines, while still addressing human issues that drive the urgency for action.

Sun Valley's Success with Pheromones Following Wildfire

Laura Lazarus
USDA Forest Service, Forest Health Protection, Region 4

Populations of Douglas-fir beetle (DFB) began to build in 2009 on Bald Mountain Ski Area (BMSA), Sun Valley Resort, in response to the 2007 Castle Rock fire. Methylcyclohexanone (MCH) anti-aggregant pheromone suppression treatments were planned because predicted resultant mortality levels within

BMSA interfered with management objectives. The 2010 and 2011 treatment strategy developed using a combination of an aerial application of MCH, and a ground deployment of MCH bubble caps to (1) protect stands of susceptible Douglas-fir (DF) on the BMSA from undesirable attack and mortality caused by DFB, and (2) to safely and effectively implement the proposed treatments. The treatments were successful on many accounts. Not only was there less DF mortality in treated areas than untreated areas, but other positives outcomes resulted from this collaborative effort between the Sawtooth National Forest, Bureau of Land Management, Sun Valley Resort, Idaho Department of Lands and Forest Health Protection.

My Experience Managing Bark Beetle Survey and Suppression Crews on Steamboat Ski Area from a District Perspective

Carl L. Jorgensen
Forest Health Protection, Intermountain Region, Boise, ID

I will discuss briefly some of the logistical challenges I faced while taking on bark beetle suppression program more than 10 years ago. Bringing in additional crews, trap tree placement, funnel trap placement, finding and peeling trees, and working across fiscal years.

HOW DID YOU CHOOSE THE SUSCEPTIBLE HOST? I DIDN'T… THE SUSCEPTIBLE HOST CHOSE ME: The effect of changes in host susceptibility on insect response—Paraphrased, "The Tango lesson"
Andy Graves moderator

The role of drought and goldspotted oak borer, *Agrilus auroguttatus*, injury on oaks in southern California

Tom W. Coleman[1], Yigen Chen[2], Nancy Grulke[3], and Steven J. Seybold[4]
[1]USDA Forest Service, Forest Health Protection, San Bernardino, CA
[2]Department of Entomology, University of California, Davis
[3]USDA Forest Service, Pacific Northwest Research Station; Prineville, OR
[4]USDA Forest Service, Pacific Southwest Research Station, Davis, CA

From 2002 to 2003, acute drought impacted the forests of southern California. Oak mortality was initially dismissed as drought-caused in San Diego County, but the goldspotted oak borer (GSOB), *Agrilus auroguttatus* (Coleoptera: Buprestidae), was linked in 2008 to the continuing tree mortality. The GSOB is an exotic pest to California that was likely introduced in the late 1990's on infested firewood from southeastern Arizona. Coast live oaks were monitored for morphological and physiological responses associated with GSOB injury inside and outside the zone of infestation. Drought stress on various size/age and infestation classes of coast live oak was measured by assessing branchlet pre-dawn and solar noon xylem water potential, leaf cell turgor potential, and water use efficiency over one growing season. The combination of canopy thinness, bole staining, and exit holes was a good predictor for elevated injury from GSOB within Principal Component Analysis. Favorable water status detected for old growth trees in the early portion of the growing season and the preference for attack from GSOB on this size class suggest drought stress is not playing a significant role in host selection. Thus, drought stress is not acting as an inciting factor. To better quantify morphological injury from GSOB across five the crown injury classes, exit holes and callus tissue were monitored on coast live oak and California black oak. The density of GSOB exit holes significantly increased on trees with greater injury and in a larger diameter size class (>76.2 cm DBH). Coast live oak had a greater density of GSOB exit holes and a greater presence of callus tissue than California black oak. Additional studies will examine the presence of tyloses in the xylem, the change in bark moisture, and assess the bark volatiles across the five crown injury classes.

Interactions among drought, tree stress, and bark beetles in forests and woodlands of the southwestern U.S.

Thomas Kolb and Monica Gaylord
School of Forestry, Northern Arizona University, Flagstaff, Arizona

Bark beetle attacks and tree mortality have increased during recent warming and drought in forests and woodlands of the southwestern U.S. Our talk synthesizes research findings from the last decade focused on the two most dominant trees of the southwest, ponderosa pine (*Pinus ponderosa*) and pinyon pine (*P. edulis*), about mechanisms of drought stress to trees and linkages between tree drought stress and susceptibility to bark beetle attack. Severe and prolonged drought causes partial cavitation of roots and shoots which limits water movement to leaves, and also causes stomatal closure which reduces photosynthesis. Months of no photosynthesis during prolonged drought combined with respiratory use of tree carbohydrates reduces tree carbon stores. Ponderosa pines killed by bark beetles (*Ips* spp. and *Dendroctonus* spp.) during recent drought had slower radial growth and fewer resin ducts in sapwood xylem than paired surviving trees suggesting that carbon depletion during drought weakened defense. Compared to surviving trees, ponderosa pines killed by bark beetles also had thicker phloem, higher concentration of alpha-pinene, and lower concentration of longifolene, whereas concentrations of beta-pinene, myrcene, 3-carene, limonene, and terpinolene were similar. These results suggest a role of semiochemicals in beetle selection of trees. Evidence from several experimental studies on ponderosa pine using mechanical wounding with and without inoculation with bark-beetle-vectored fungi (*Ophiostoma minus, Grosmannia clavigera*) and before and after bark beetle (*D. adjunctus*) attacks induced by pheromone baits suggest that physical resin defense (e.g., resin flow from phloem wounds) and monoterpene composition are primarily constitutive with little induction. Recent results from an experimental manipulation of water availability to mature pinyon pines strengthen interpretations of field observations concerning a role of drought in pinyon pine susceptibility to *Ips confusus* attacks. Two years of experimental drought (55% of ambient precipitation) increased bark beetle attacks resulting in about 80% tree mortality; trees killed by bark beetles had smaller resin ducts than surviving trees. The cumulative results of these studies strongly suggest that ponderosa and pinyon pines in the southwestern U.S. occur on the left or stressed side of the growth-defense framework where stress reduces carbon assimilation, growth, and defense. The process of host selection by bark beetles in southwestern woodlands and forests is a notable knowledge gap.

THE ROLE OF ABIOTIC AND BIOTIC STRESSORS IN JEFFREY PINE SUSCEPTIBILITY TO BARK BEETLE

Nancy Grulke[1], Andy Graves[2], and Steven Seybold[3]
[1]USDA FS, Pacific Northwest Research Station, Prineville, OR
[2]USDA FS, Forest Health Protection, Albuquerque, NM
[3]USDA FS, Pacific Southwest Research Station; Davis, CA

Physiological drought stress triggers a cascade of responses that, depending on the level of stress experienced, may or may not predispose the tree to a successful bark beetle attack. Our hypotheses were that 1) under moderate physiological drought stress, resin production is stimulated and turgor potential of the bole is sufficient to express the resin, but 2) under severe tree drought stress, resin production is highly upregulated, but there is insufficient turgor potential in the bole cambium to express the resin (that acts as a physical barrier to bark beetle attack). In order to test this, mature Jeffrey pine (*Pinus Jeffreyi* Grev & Balf.) along a 600 mile latitudinal gradient was studied on the eastern slope of the Sierra Nevada over three years with differing levels of soil moisture and evapotranspirational deficits. At each of 5 locations, stand density and distance to nearest neighbor were used as 2 measures of biotic stress (competition). Tree attributes used to determine susceptibility to bark beetle included measures of physiological drought stress, resin quality and exudation flow rates, and whether or not trees were attacked by Jeffrey pine beetle (*Dendroctonus Jeffreyi* Hopkins).

At the northern-most site (Lassen NF), trees in dense stands were more physiologically stressed than in thinned stands. At the southern 4 sites (Tahoe, Inyo, Sequoia, and San Bernardino NF), lower % of average precipitation increased tree drought stress, but there was no difference in tree stress between dense and thinned stands. Jeffrey pine that was attacked was significantly closer to another single tree (e.g., higher tree-tree competition), but had fewer trees within its sphere of influence (e.g., in lower density stands). Physiological tree drought stress as measured in the canopy was correlated to lower turgor potential in bole phloem, a specific signature of resin quality, and low resin exudation flow. In this study of 530 trees, 9% of the trees were attacked by Jeffrey pine beetle, primarily in the year following drought; 7% of the attacks occurred in thinned stands; and there was no trend of increasing mortality with decreasing latitude. In terms of initial attack in a stand, Jeffrey pine beetle may be able to detect the differences in resin quality observed in drought-stressed trees. Remote detection of tree drought stress using high resolution, multispectral imagery is demonstrated.

DEFOLIATORS AND BEETLE/DEFOLIATOR INTERACTIONS
Laura Lazarus moderator

Douglas-fir Beetle Activity Following Severe Defoliation at Flesher Pass, Montana

Nancy Sturdevant and Sandy Kegley
[3]USDA Forest Service, R1, Forest Health Protection

Bark beetle-caused mortality is sometimes associated with significant defoliation in conifer forests. Few recent examples of successful thinning treatments have been documented in areas heavily impacted by western spruce budworm. The objective of this study was to monitor defoliation and bark beetle mortality on 267 trees in the northern region on Flesher Pass over time and demonstrate the effectiveness of silvicultural treatments aimed at reducing budworm impacts. High bark-beetle caused mortality occurred in stands with very high levels of budworm-caused defoliation. Adjacent stands that were thinned showed very little damage from budworm over time and had no bark beetle-caused tree mortality.

Mortality following the recent pine butterfly outbreak on the Malheur National Forest

Ari DeMarco[1], Rob Flowers[2], Dave Shaw[1], Lia Spiegel[3]
[1]Oregon State University, Corvallis, OR.
[2]Oregon Department of Forestry, Salem, OR.
[3]USDA Forest Service, R6, Forest Health Protection, La Grande, OR.

The pine butterfly, *Neophasia menapia*, (Lepidoptera: Pieridae) has recently increased severe defoliation in central Oregon from ~44,000 acres in 2010 to ~250,000 acres in 2011, and then declined to ~100,000 acres in 2012 in an area of ponderosa pine south of John Day and north of Burns, Oregon on the Malheur National Forest mostly. We initiated this study to assess the levels of tree mortality and increased fuels following a severe, landscape-scale defoliation by the pine butterfly in these forests. We have established 48 permanent plots so far over a range of defoliation intensities, stand types and structures within the affected area. For each plot, we described or will describe: 1) stand structure, 2) fuels, 3) herbivory in all trees > 5 cm, estimated by crown thirds. Other remotely-sensed data will be used to complement ground surveys and provide additional information on climate or other factors. Permanent plots will be evaluated annually for five years (2012-2017), and a final 10 year (2022) visit will include growth, mortality and increment core data on basal area growth for each tree. So far, there is little indication that bark beetles are following this defoliation event with tree attacks and mortality. Bark beetle mortality was very rare on the plots, although we have observed patchy mortality and decline of some trees in the region, especially in the repeatedly defoliated areas. It was not certain this mortality and top dieback was caused by bark beetles, although *Dendroctonus valens* was common on some of these trees.

THE BARK BEETLE TECHNICAL WORKING GROUP: CONTINUING A DISCUSSION OF NEEDS, ASSESSMENTS, AND RESEARCH PRIORITIES

Chris Fettig and Carl Jorgensen moderators

Attendees were in strong support of BBTWG; several issues were discussed. As a result, a small group (Blackford, Fettig, Jorgensen, Munson, Steed, Willhite; others are welcome) worked to address some of these in several follow-up conference calls.

One comment repeatedly voiced during this workshop concerned the need to more clearly define the membership, mission and goals of BBTWG. To that end, an edited draft of the Mission Statement was developed and submitted to review and comment to the BBTWG and WFIWC mailing list. This draft was also posted at the BBTWG website.

There was also much discussion about the lack of participation from researchers in recent years (both FS R&D and university) during this workshop, and how this has negatively impacted knowledge sharing during the annual meeting. To that end, we are considering ways in which to increase opportunities for researchers to participate (e.g., consolidating BBTWG with other meetings, changing the time of year that the meeting is held, etc.), and would appreciate additional thoughts in this regard at the next meeting.

In the meantime, if you have additional thoughts or comments please submit them to either Carl Jorgensen (cljorgensen"at"fs.fed.us) and/or Chris Fettig (cfettig"at"fs.fed.us). At the future BBTWG meetings as one of the agenda items, we will continue the discussion on how to adapt the BBTWG to accomplish its mission.

POST-EPIDEMIC: WHAT WE WISH WE KNEW THEN / WHAT WE THINK WE KNOW NOW

Danielle Reboletti moderator

Interactions between Stem Diameters and *Dendroctonus* Beetle-Caused Tree Mortality in Western Yellow Pine Forests

Joel M. Egan
Forest Health Protection, USDA Forest Service

Experimental research and monitoring studies from the past 10 years were evaluated to assess interactions between stem diameters and bark beetle-caused tree mortality within western yellow pine forests. The primary mortality agent for these forest types were the mountain pine beetle (*Dendroctonus ponderosae* Hopkins) (MPB), western pine beetle (*Dendroctonus brevicomis* LeConte) (WPB), and Jeffrey pine beetle (*Dendroctonus jeffreyi* Hopkins) (JPB). Complexes of *Ips* spp. and *Dendroctonus* beetles from southwestern yellow pine forests were not included in this analysis.

In total eight assessments were evaluated to determine common patterns of mortality within stem diameter classes in ponderosa and Jeffrey pine forest types. These assessments included: MPB in Colorado Front Range, MPB in Black Hills of South Dakota, WPB throughout Sierra-Nevada Mountains of California, MPB in the Warner Mountains of California, MPB in the Elkhorn Mountains of Montana, MPB in the Bitterroot Mountains of Montana, and JPB throughout the Sierra-Nevada Mountains of California.

Information from these assessments, whether they were an experimental research study or a monitoring evaluation, were each treated as a case study as the temporally specific environmental conditions that influence beetle-caused tree mortality fluctuate from one outbreak to the next and by spatial location. These conditions include variations in the degree of drought severity and persistence, level of bark beetle population pressure, level of natural enemy populations, etc. As conditions varied extensively within each of these assessments, common parameters found within these diverse locations are considered robust and applicable to ponderosa and Jeffrey pine forests under an array of divergent temporal conditions.

Findings from this assessment indicate yellow pine mortality caused by *Dendroctonus* beetles that reached all outbreak population stages reported maximum mortality rates of 40-50% for all host stems within study sites. This is less than has been observed for mountain pine beetle-caused mortality in other forest types such as 80-100% mortality levels within lodgepole and whitebark pine dominated stands.

Stands where outbreaks originate and progress had an abundance mid-sized stems within a 8-15" diameter at 4.5 feet in height (DBH). Where larger trees were present mid-sized stems had the highest level of mortality. Conversely, stems greater than 20" consistently had reduced rates of mortality. This discussion excludes diseased and decadent large-diameter stems that are pre-disposed to beetle colonization. The studies that monitor a temporal progression of mortality indicated mid-sized stems were attacked during beginning outbreak stages and larger stems (> 20" DBH) were attacked after populations increased and drought conditions persisted.

We hypothesize that the common findings from multiple locations and various *Dendroctonus* mortality agents occurred due to the following. Firstly, yellow pines within the 8-15" diameter class represent a compensation point where stems are expansive enough to have phloem thickness levels to support beetle population amplifications while being small enough that they lack physiological mechanisms for drought tolerance or avoidance that larger stems possess. Thus, these mid-sized stems represent a 'sweet spot' for beetles and are often attacked early during an outbreak after having temporary physiological stress induced by drought conditions. The larger diameter stems having reduced mortality levels during beetle outbreaks is hypothesized to occur as they have enhanced resilience to physiological drought stress. As these trees are larger, they have more expansive root systems and overall growing space allowing greater access and efficiency with water resources.

Overall, these findings differ from the traditional description that bark beetles often cause mortality in physiologically stressed diseased, decadent, or otherwise weakened trees at low or endemic population levels and can kill any tree at high or epidemic population levels. This description should be limited to MPB in lodgepole or whitebark pine forest types. There is a growing body of evidence that large diameter yellow pine stems exceeding 20" DBH can have enhanced resilience even when exposed to epidemic beetle populations. While they appear to have enhanced resilience, some of these stems were colonized during peak epidemic years of studies evaluated, likely as cumulative drought effects eventually reduced defensive capacity below beetle-resilience thresholds.

Will outbreak MPB impact adjacent alternate pine hosts? MPB host preference between lodgepole and ponderosa pines in Colorado

Daniel R. West[1], Jenny S. Briggs[2], William R. Jacobi[1]
[1]Colorado State University, Dept. Bioagricultural Sciences and Pest Mgmt., Fort Collins, CO
[2]US Geological Survey, Geosciences and Environmental Change Science Center, Lakewood, CO

We compared MPB-caused mortality in lodgepole and ponderosa pines as an epidemic moved toward ponderosa pine dominated stands along the Front Range Mountains, CO. No differences in MPB-caused mortality were detected between the two host species in any given year, though mortality varied across years (2004-2011). Previous year's MPB-caused mortality (basal area) in both lodgepole and ponderosa pines predicted the next year's ponderosa pine mortality, though only the previous year's MPB-caused lodgepole pine mortality predicted the next year's lodgepole pine mortality. We conducted controlled-field choice experiments, with beetles from either lodgepole or ponderosa pines offered in a caged arena to cut logs of both lodgepole and ponderosa pines. MPB preferred ponderosa pine 2:1, though fecundity did not differ between the two pines. In choice-bioassays, individual MPB preferred ponderosa pine over lodgepole pine bark/phloem units. We compared quantitative and qualitative host defenses of lodgepole and ponderosa pines and found ponderosa pines had four times the constitutive oleoresin flow than lodgepole pines. No differences were detected in total monoterpene quantities, though limonene, β-phellandrene, and cymene were all greater in lodgepole pine oleoresins. This study suggests that MPB prefers ponderosa pine over lodgepole pine, particularly under reduced or debilitated host defenses.

Impacts of Outbreaks on Forests and Communities

Christopher J. Fettig
USFS, Pacific Southwest Research Station, Davis, CA

Phytophagous insects impact virtually all forest processes and uses by influencing ecosystem structure and function through regulation of certain aspects of primary production, nutrient cycling, ecological succession, and the size, distribution and abundance of forest trees. Elevated activity reduces tree growth and hastens decline, accelerates rates of tree mortality, alters species composition and shifts plant associations. The nature and extent of impacts depend primarily on the type of insect activity, size and distribution of the insect population, resource affected, and metric used for evaluation. In western forests, bark beetles (Coleoptera: Curculionidae) are primary disturbance agents. Outbreaks may impact timber and fiber production, water quality and quantity, coarse woody debris, fish and wildlife habitat and populations, recreation, grazing capacity, real estate values, biodiversity, carbon storage, endangered species, cultural resources, fuels and fire behavior, human safety and other resources. I highlight several notable impacts of bark beetle outbreaks on forests and communities in the western U.S. Examples are drawn for work executed on mountain pine beetle in the Intermountain West and on western pine beetle in Southern California.

WESTERN NORTH AMERICAN DEFOLIATOR WORKING GROUP: WHERE DO WE GO FROM HERE?

Members Present:

Kathy Sheehan (moderator)	Amanda Grady
Bruce Hostetler	Iral Ragenovich
Lia Spiegel	Mike Johnson
Laura Lazarus	Tom Eckberg

David Beckman	Amy Gannon
Beth Willhite	Glenn Kohler
Stephen Nicholson	Rob Flowers
Nancy Sturdevant	Sandy Kegley
Connie Mehmel (note taker)	Adam Polinko

WNADWG history

The WNADWG was originally organized to review defoliator control projects. John Wenz was the chair. Currently it is a loose organization that meets in late November or December to review condition reports and discuss new defoliator issues. The date is set to coincide with a time when Aerial Detection Survey data is available. The group did not meet in 2011 or 2012. Should we start it up again?

Folks who were doing the DFTM Early Warning System trapping used meet to review results and plan the next year's trapping program. Later, the group evolved to include other defoliators.

When the Special Technology Development Projects (STDP) program started, WNADWG became one of the technical committees giving advice to that program. However, WNADWG no longer advises the STDP program.

Possible meeting option: coordinate with BBTWG

We discussed meeting jointly with the Bark Beetle Technical Working Group. BBTWG meets annually (usually in October) to provide input regarding research needs. It is a small group, and prefers to remain focused on bark beetles. Currently there are few FS researchers working on defoliators, and no more emphasis on aerial application.

Beth attended the BBTWG last fall, and currently chairs the group. They will meet in October 2013 in the Hood River, OR, area. While they prefer to meet separately, they are open to coordinating with WNADWG to have "back to back" meetings in the same location.

Why have working group meetings?

- Exchange knowledge across regions, learn from each other, mentor new people.
- Provide formal training as needed.
- Identify partners for projects or research; general coordination.
- Share data and publications.
- Provide group input on issues that should be raised upward.
- Identify research needs (i.e. climate change).
- Incentive to write up reports.
- Provide ongoing documentation for the future.
- Brainstorm to address issues raised by participants.

Meeting logistics

Be sure researchers are on the email list, i.e. Rob Progar (pine butterfly, balsam woolly adelgid), Ann Lynch (western spruce budworm, spruce aphid). The email list should be standardized; it is now cumulative (based on who attended the most recent meetings).

Should we meet every 2 years? Probably not. There is a sense of urgency about outbreaks.

What time of year should we meet? For 2013, we will coordinate with the BBTWG and meet at Hood River, OR, in October. October is a difficult time for folks working on aerial survey. Traditionally we have met in late November (after the Thanksgiving holiday week) or during the first 2 weeks in December, when aerial survey results are usually available and few other meetings are scheduled. After coordinating our meeting with the BBTWG meeting for 2013, we'll evaluate whether to continue synchronizing these two meetings.

We will keep the groups separate. Tentatively, we plan to start Monday afternoon (10/28/2013) and meet for 1½ days.

Topics:

- Highlights by defoliator (no condition reports)
- Condition reports as handouts (1 page limit)
- Emerging issues
- Posters

Field trip? No; it's the wrong time of year.

No powerpoints – though a few images of new insects or damage are fine. This will be a round table discussion.

Assignments:

- Beth Willhite – 2013 local arrangements
- Kathy Sheehan – maintain email list (contact ksheehan"at"fs.fed.us) and website (www.fs.usda.gov/goto/r6/fhp/wnadwg)
- Nancy Sturdevant – program chair (2013-2014)
- Glenn Kohler – program chair (2015-2016)
- Stephen Nicholson – will send Kathy a list of Canadians who might be interested

Location will be rotated. To minimize travel costs, meeting locations need to be easy to access.

What about a name change? (No other names were proposed.)

ENHANCING ENOMOLOGY PHOTOGRAPHY SKILLS AND BUGWOOD TECHNOLOGIES UPDATE

Bill Ciesla and Keith Douce, Moderators

Photography for Forest Health Specialists

Bill Ciesla, Forest Health Management International, Fort Collins, CO

Photography is a key part of being a forest health specialist. We use photos for various reports and publications. They are a vital part of the training we provide to clients and we use photos to make presentations to peers, resource managers and the public. A good photo can also be of help in identifying a pest species.

General subject areas for which we need photos include the pests themselves in their various life stages; the damage they cause, from a landscape, stand, tree and branch perspective; the various activities we use to monitor and manage forest pests and, finally, examples of healthy forests, the intended end result of our work.

A basic principle of photo composition is to subdivide the horizontal and vertical edges of the photo frame into thirds and drawing connecting lines to the opposite edge of the image. Place the subject of interest at one of the four intersections of the horizontal and vertical lines. Have the subject facing into the photo. Avoid placing the horizon line across the center of the photo. Instead place the horizon line across the lower or upper third of the image. Keep the horizon line level. One can create a three dimensional effect by framing the image with tree branches and foliage. Include people in your photos. They create interest and add scale to the image.

Close up photography, usually with a macro lens, is a key aspect of photography for entomologists and plant pathologists. Depth of field, the portion of the subject that is in focus, is a key consideration in close up photography. To ensure that the subject is in focus, I use a small lens opening, at least f22. My primary working settings for close ups are: ISO 200, shutter speed 1/200 with a lens opening ranging from f22-f36. I use a fill in flash, which in the absence of foliage or other objects provides a black background and a clear, crisp image. This approach works well unless I am dealing with dark colored insects that must be photographed against a light or natural background. For these conditions, I use the close-up (macro) exposure setting on my camera.

I do minimal photo editing on my images and believe that a good image requires little or no fixing. The one time I do edit images is when I take photos of forest damage from a small airplane. These are often hazy and have a less than desirable color balance. To adjust for haze, I use the “Auto Contrast” and “Auto Color Correction” commands available on Adobe Photo Shop Elements.

Winning Techniques in Landscape Photography with Applications to Forestry

Ronald F. Billings, Texas A&M Forest Service, College Station, TX

This presentation discussed and illustrated techniques I have found useful for producing winning landscape photographs, using various images I have taken during my career. My camera equipment has evolved over the past 40 years from 35mm single lens reflex cameras (slide transparencies) to digital cameras. I am currently using a Nikon D7000 with lenses that include a wide angle (12-24mm Tokina), zoom (18-200mm Nikkor), and telephoto lenses (70-300 Tamron).

Techniques to improve composition involve the rule of thirds (i.e., not placing the primary subject in the center of the image), use of natural frames and foreground features, leading lines, backlighting, taking advantage of various weather conditions (fog, rainbows, clouds, etc.), different perspectives, and inclusion of people in landscape photos. The quality of light was discussed, particularly the “magic hours” (approximately one hour after sunrise and one hour before sunset). Photos taken during the magic hour have warm, glowing colors that make landscape images particularly striking. The use of a fill flash for photos taken outdoors was mentioned as a means to offset harsh mid-day shadows on faces and other objects. Many photos, such as waterfalls, towers, and trees, benefit if taken in a vertical format. The key to taking winning landscape photos rests with combining two or more of the basic landscape elements mentioned above in a single photo and taking the photo when natural light is optimal. Developing a good "eye" for landscape opportunities and having your camera always at hand also are important.

I use the Adobe Photoshop software program occasionally to adjust colors or sharpness, to crop, or to eliminate distracting elements such as power lines or trash from the image (cloning tool). However, I prefer to take the time and effort to capture images that require little or no post processing.

Using Mobile Apps, Wikis, Image Systems and Partnerships to Advance Invasive Species, Forest Health & Forestry Education

G. Keith Douce, Co-Director Center for Invasive Species & Ecosystem Health and
Professor, College of Agricultural and Environmental Sciences, University of Georgia,
Tifton, GA

The mission of **THE CENTER FOR INVASIVE SPECIES AND ECOSYSTEM HEALTH** (http://www.bugwood.org/about.html) [The Bugwood Center], based at the University of Georgia, is to serve a lead role in development, consolidation and dissemination of information and programs focused on invasive species, forest health, natural resource and agricultural management through technology development, program implementation, training, applied research and public awareness at the state, regional, national and international levels.

The Bugwood Network (www.bugwood.org) is the information technology component of The Bugwood Center and now consists of over 30 inter-related websites focused on education. The Bugwood Network's ForestryImages (www.forestryimages.org) system is probably the most familiar to forest health professionals. This presentation provided attendees with an update on new features, capabilities and developments made to The Bugwood Network in recent years.

The **FOREST PESTS OF NORTH AMERICA** website (http://www.forestpests.org/) was redesigned late in 2012 and is intended to be used by homeowners, land managers, volunteers, urban foresters, county agents and outreach educators interested in identifying pests and managing their trees and forests.

THE **BUGWOOD IMAGE DATABASE SYSTEM** (http://images.bugwood.org/) archives and serves over 188,000 images that users can find, download and use through one of a suite of user-focused web-interfaces. The speaker discussed: advanced user-searches; the LIGHTBOX; online image upload; photographer user-statistics; Image Recruiting; and the Institutional Archives.

BUGWOODWIKI (http://wiki.bugwood.org/) enables authors to access BugwoodImages systems to incorporate images into the educational materials and is used many educators and volunteer groups across the U.S. to build and deliver to users within and across several states.

The web-based **EARLY DETECTION AND DISTRIBUTION MAPPING SYSTEM** (EDDMapS - www.eddmaps.org) is fast, easy-to-use and doesn't require Geographic Information Systems experience.

EDDMapS combines data from other databases, organizations and citizen scientists to create a national network of invasive species distribution data.

The **BUGWOOD SMARTPHONE APPS** (currently 18) include Field Guides and Reporting Apps that complement and expand ongoing education and outreach programs. The Apps are fully integrated with other Bugwood systems and are available for iOS and Androids systems and incorporate georeferenced reports with images. Established EDDMapS protocols are used for verification of reports, follow-ups and access/viewing of reported data. EDDMapS combines data from other databases, organizations and citizen scientists to create a national network of shared invasive species distribution data.

REGIONAL INSECT CONDITIONS REPORTING

Cyndi Snyder moderator

R1-Northern Rockies

Chris Hayes, USDA Forest Service, Forest Health Protection, Missoula, MT

In 2012, USFS, Forest Health Protection and states surveyed over 36 million acres from the air in R1 to detect current tree mortality and defoliation. Mountain pine beetle-caused mortality decreased greatly in many areas as susceptible hosts were no longer available. Overall, slightly less than 1 million acres were recorded with mortality from bark beetles, of which 985,000 acres were caused by mountain pine beetle. Areas that continue to have active MPB populations and resulting high levels of tree mortality include Clearwater, Idaho and Shoshone counties in Idaho and Beaverhead, Granite, and Ravalli counties in Montana. Mountain pine beetle in whitebark pine has decreased in 2012 with a lack of living trees to attack and lower beetle populations, and damage from other bark beetles remained at relatively low levels.

Defoliation by western spruce budworm and Douglas-fir tussock moth decreased, but budworm populations are still defoliating large areas of Douglas-firs throughout Region 1 (>1.5 million acres) and increasing Douglas-fir susceptibility to Douglas-fir beetle. Detection of Douglas-fir beetle is being hampered by defoliation which makes detection of fading trees difficult. Douglas-fir tussock moth defoliation in Idaho has dropped significantly, however. The exotic insect larch casebearer was observed at low levels throughout larch stands, and Balsam wooly adelgid continues to be found in northern Idaho (13,154 acres). Balsam wooly adelgid has not been detected by aerial survey in Montana to this point, but ground surveys have identified it in some areas in the far western portion of the state and monitoring efforts will be increased in Montana in 2013.

R2-Rocky Mountain Region

Robert Cain, Entomologist, USDA Forest Service, Forest Health Protection, Rapid City, SD Angie Ambourn, Entomologist, USDA Forest Service, Forest Health Protection, Rapid City, SD

Bark beetles continue to cause landscape level changes in the Rocky Mountain Region. Mountain pine beetle was active on over 400,000 acres in the Rocky Mountain Region and has slowed down in many areas of Colorado and Wyoming as large pine trees have been depleted in the core outbreak areas. Forested areas affected by mountain pine beetle expanded by 31,000 acres in Colorado, 53,000 acres in Wyoming and 11,000 acres in South Dakota. In Nebraska, mountain pine beetle activity documented in ponderosa pine on the Wildcat Hills in 2011 was not observed by the 2012 flights. Spruce beetle activity was detected on 311,000 acres in Colorado and 29,000 acres in the USFS Region 2 portion of Wyoming in 2012. Of these 183,000 acres are in areas not previously mapped as having spruce beetle activity (new acres). This increase of activity is indicative of a rapidly expanding outbreak. In some areas, the outbreak has moved through entire drainages in the course of one year. In the most heavily impacted drainages, nearly every mature spruce has been killed from the creek bottoms to the high elevation krummholz. Douglas-fir beetle activity was detected on 27,000 acres in Colorado and 11000 acres of Wyoming. Levels of Douglas-fir tree mortality vary widely from scattered mortality in some stands to almost the total loss of mature Douglas-fir in others. Western balsam bark beetle activity was detected on 221,000 acres in subalpine firs across Colorado and on 14,000 acres in the USFS R2 portion of Wyoming.

Defoliators were also active in the Rocky Mountain Region. Western spruce budworm activity increased in Colorado in 2012. Aerial surveys detected 217,000 acres affected in the state in 2012. Activity was found mainly on the San Isabel, San Juan, and Rio Grande National Forests. In the USFS R2 portion of Wyoming, 16,000 acres of western spruce budworm damage was detected with activity concentrated in the NW corner of the state. Rusty Tussock Moth in Wyoming's Big Horn Mountains was still active in lodgepole pine but damage was not visible from the air in 2012.

R3 – Southwest Region
New Mexico Service Station

Crystal Tischler, Biologist USDA Forest Service, Forest Health Protection, Albuquerque, NM
Daniel Ryerson, Forest Health Specialist, USDA Forest Service, Forest Health Protection, Albuquerque, NM
Andy Graves, Entomologist USDA Forest Service, Forest Health Protection, Albuquerque, NM

The 2012 surveys encompassed approximately 9.9 million acres of New Mexico's forests and woodlands, including approximately 1.4 million acres of forested state and private lands and an additional 1 million acres of state and privately owned piñon-juniper woodlands. Statewide results of the surveys are briefly described here:

Overall bark beetle-caused tree mortality continues to expand across most forest types. Across the state we experienced rises in most bark beetle activity categories. Ponderosa pine forest types suffered the most bark beetle mortality with over 123,000 acres mapped across New Mexico, primarily on the Lincoln and Gila NF's. The mixed conifer forest type experienced the biggest increase to nearly 38,000 acres mapped in 2012. Mortality caused by the piñon ips beetle and by the spruce beetle each increased significantly this year, while corkbark fir mortality was less than observed in 2011.

Defoliation by western spruce budworm continues to affect a substantial portion of northern New Mexico, though numbers have dropped slightly this year with 475,000 acres mapped.
Aspen decline was observed on nearly 3,200 acres this year. The acres mapped this year are either new areas of decline or areas where the aspen decline has progressed from light to heavy. Aspen defoliation increased from 82,000 acres in 2011 to 135,000 acres in 2012.

R3 – Southwest Region
Arizona Service Station

Amanda Grady, Entomologist USDA Forest Service, Forest Health Protection, Flagstaff, AZ
Steve Dudley, Biological Science Technician, USDA Forest Service, Forest Health Protection, Flagstaff, AZ

The 2012 aerial detection surveys (ADS) encompassed approximately 10.6 million acres of Arizona's forests and woodlands, including approximately 700,000 acres of state and private lands. Bark beetle activity in Arizona increased statewide from approximately 6,500 acres of tree mortality mapped in 2011 to just about 55,200 acres detected in 2012. Approximately 97% of the bark beetle damage occurred in ponderosa pine forests. Most of the bark beetle activity was mapped on the Coconino and Kaibab National Forests and along the Mogollon Rim in northern Arizona. Much of this beetle-caused tree mortality was related to recent disturbance events and drought stress. This year we mapped about 31,000 acres of foliage discoloration associated with drought stress, most of which occurred on the Coconino National Forest and state and private lands. A late season frost damaged emerging vegetation across much of Arizona's forests, in total approximately 22,500 acres with frost damage were detected during the ADS. Overall, defoliator activity increased from approximately 7,500 acres impacted in 2011 to nearly 11,000 acres mapped in 2012. Pine sawflies, western spruce budworm, western tent caterpillar, large aspen tortrix and pine defoliating weevils in the genera's Scythropus and Magdalis caused most of the damage. Pinyon needle scale, tamarisk leaf beetle, sycamore lace bugs, Leuschner's tussock moth and leafhoppers were some of the minor agents causing detectable defoliation during the 2012 ADS. Douglas-fir tussock moth early warning trap catches averaged 49 moths at a site in the Pinaleno Mountains in southeastern Arizona; however, no visible defoliation was detected via ADS this year. Light and pheromone trapping for pandora moth north and south of Grand Canyon National Park indicate increasing populations, however, visible defoliation has not been detected from ground or aerial surveys. Aspen decline increased from about 40,000 acres mapped in 2011 to approximately 62,000 acres mapped in 2012; most of the damage was observed north of the Grand Canyon and on the Navajo Nation in the Chuska Mountains.

R5 – Pacific Southwest Region

Beverly Bulaon, Entomologist USDA Forest Service, Forest Health Protection, Sonora, CA

Approximately 511,000 acres were found to be affected by insects and diseases in California, a decline from 2011. An estimated 1.78 million trees were killed. The major bark beetle of concern was the continuing outbreak of mountain pine beetle-caused mortality in high elevation whitebark and lodgepole pines.   Several defoliators did not cause large-scale damage but significant enough to be detected in aerial surveys.

Invasive insects continue to threaten and successfully kill trees in California.   The invasive polyphagous shot hole borer was first detected in 2003 in southern California, but only recently has been found associated with tree injury.   Sudden Oak Death continues to be found in new locations throughout its host ranges; associated mortality increasing by six fold since 2011.   Sudden Oak Death was observed on 54,400 acres with estimates of 376,000 dead oaks and tanoaks.   Continued mortality due to invasive Goldspotted oak borer continues its slow spread through San Diego County, with new infestations found in adjoining Riverside County.   Balsam Wooly Adelgid (BWA) was detected in Mendocino County in Grand Fir for the first time since 1986.

R6 – Pacific Northwest Region

Bill Schaupp, Entomologist USDA Forest Service, Forest Health Protection, Central Point, OR

In 2012, aerial detection surveys were completed cooperatively by state and federal staff on over 43 million acres of forests in Washington and Oregon covering all ownerships, consistent with recent years' surveys. These surveys indicated that over 560,000 acres were affected by bark beetles and the flatheaded fir borer in 2012, an increase from over 522,000 acres reported in 2011, and that about 930,000 acres were affected by major defoliators and hardwood impacts, a decrease from about 1,220,000 acres reported in 2011.

R10 – Alaska Region

James Kruse, Entomologist USDA Forest Service, Forest Health Protection, Fairbanks AK
Elizabeth Graham, Entomologist USDA Forest Service, Forest Health Protection, Fairbanks

Alaska Region Forest Health and Protection staff and cooperators identified over 490,000 acres of forest damage from insects, diseases, declines and selected abiotic agents on the 28.5 million acres surveyed out of the total 127 million acres of forested land in 2012. The total damaged acreage observed is down by 24% from 2011 levels, and down significantly compared to 2010. Much of the change since 2010 is due to substantial decreases in aspen and willow leaf mining and defoliation, less activity by spruce aphid in Southeast Alaska, and reduced acreage of newly-killed spruce by bark beetles. However, defoliator damage to birch, cottonwood and other hardwood species is escalating.

The aspen leaf miner, which was previously ranked as the number one pest in terms of acreage damaged, continued to decrease in activity with a 50% reduction in acreage detected from last year. There was also >50% reduction in the acreage of alder defoliation. Defoliated acreage for birch, cottonwood, and spruce increased. The greatest amount of defoliation occurred on birch (177,800 acres affected); about half on birch trees and half on dwarf birch shrubs. A variety of insects contributed to this defoliation, including several geometrid moth species, the rusty tussock moth, leaf rollers, and leaf beetles. The greatest amount of birch defoliation occurred on the Kenai and Alaska Peninsulas and in Interior Alaska. The acreage affected by spruce aphid continues to decrease; another cold winter may push this pest to undetectable levels next year. A moderately sized outbreak of spruce budworm near Ninemile Slough (Yukon River) may indicate that the population of this species is on an upward trend, but cool, wet weather over the next few years may help to control their population. Spruce beetle damage has continued to decrease to the lowest level in decades, with fewer than 17,000 acres detected. A series of severe wind events along the upper Tanana Valley in mid-September resulted in a 70-mile-long swath of stem breakage, blowdown and tipped spruce and hardwoods over the region. It is estimated that close to 1.4 million forested acres were damaged across the region. The northern spruce engraver is expected to capitalize on the increase in brood material from these storms during the next few years, thereby increasing the chance of a future outbreak. Customs and Border Protection continues to intercept Asian gypsy moth (AGM) to prevent its introduction to Alaska. A bulk carrier vessel was intercepted near Ketchikan that was transporting AGM egg masses. The ship was not allowed into port until all egg masses were destroyed. AGM could be devastating to Alaskan forests if established.

POSTER PRESENTATION ABSTRACTS

Novel acoustic technique to control bark beetles

Nicholas Aflitto and Richard W. Hofstetter
School of Forestry, Northern Arizona University, Flagstaff, AZ

Outbreaks of bark beetles are some of the most significant biotic disturbance to forest ecosystems, and typically lead to extensive economic losses, complete transitions of forest communities, and negative impacts on local recreation and forest usage. New acoustic technology has the potential to minimize some of the impacts of these species in trees. Our objective is to create acoustic inputs to deter bark beetles from entering healthy trees, and to test the efficacy of the acoustic devices for management and controlling bark beetles. We tested two hypotheses: (1) Acoustic treatments will influence entry of bark beetles into trees; (2) Specific sounds affect bark beetles differently. Hypothesis 1 was partially supported, and Hypothesis 2 was supported by this study. The 'wood borer' sound treatment reduced colonization rate of the pioneer sex of *D. frontalis* and *D. brevicomis*. Also, the 'stress' sound treatment reduced colonization of *D. frontalis* beetle, and the 'artificial' sound increased colonization of *D. brevicomis* beetles. None of the acoustic treatments had an effect on entry by *Ips pini*. This technology could add to the arsenal of tools forest managers use to control bark beetles, provide one of the few non-chemical and environmentally friendly methods of bark beetle control, and expand the usage of this device for wood infesting insect pests in the western and southern United States.

Cutting infested pines into unpeeled sections: a population-reduction tactic for managing mountain pine beetles in the Black Hills

John Ball, South Dakota State University, SD Extension Service and SD Department of Agriculture, Kurt K. Allen and **Angie Ambourn** R2 FHP, Rapid City, SD

Mountain pine beetle is the most aggressive insect killer of pines in the western U.S. Over the last 12 years the Black Hills has experienced significant pine mortality from this insect. Suppression activities such as cutting infested trees into smaller pieces and exposing them to sunlight can be an effective tool for reducing mountain pine beetle populations. The objective of this study was to determine effects of cutting infested ponderosa pine trees into 60-70 cm unpeeled sections on MPB population reduction in the Black Hills. Four 60-70 cm sections of ponderosa pine were sampled from 4 sites on the Black Hills National Forest (BHNF) and Custer State Park (CSP). Whole trees were also felled/limbed, felled/left whole and cut into 2 m sections at one site on the BHNF and one site at CSP. Live beetles were sampled from beneath a 15.5 cm x 15.5 cm piece of bark on both the top and bottom; standing infested trees were also sampled on north and south sides of trees. Results comparing cut sections to the control were analyzed using Tukeys HSD test. Results show that cutting in to small (60-70cm) sections early in the season is an effective tool for reducing the local beetle population as a stand level treatment.

Guatemala: Place of Trees; Place of Bark Beetles

Ronald F. Billings
Texas A&M Forest Service, College Station, TX 77845

Guatemala is one of the most diverse and fascinating countries in Central America. The country gets its name from translation of a Mayan term, meaning "place of many trees." Indeed, this country has a greater diversity of tree species than any other Central American country, due to a terrain that extends from sea level to the tops of numerous volcanoes that top out at 3,500 to 4,200 m. Guatemala hosts over 8,000 species of plants in 19 different ecosystems ranging from the mangrove and tropical hardwood forests on both coasts to the pine forests of the mountainous interior to the cloud forests at higher altitudes. It also has a wide diversity of bark beetles that attack and kill conifers. These native pests include at least eight species of tree-killing *Dendroctonus* (including one putative new species, *D. woodi*) and several species of *Ips* engraver beetles. Recent efforts to train Guatemalan foresters on bark beetle identification and management are discussed.

"Outbreaks" of Leaf Beetles (Coleoptera: Chrysomelidae and Megalopodidae) in Colorado–2012

William M. Ciesla[1], Justin Backsen[2] , Brian E. Howell[2] and Patricia M. Ciesla[1]
[1] Forest Health Management International, Fort Collins, CO
[2] USDA Forest Service, Rocky Mountain Region, Lakewood, CO,

Damage caused two leaf beetles of the family Chrysomelidae (*Altica* sp. and *Chrysomela aeneicollis*) and one of the family Megalopodidae (*Zeugophora scutellaris*) were detected on narrow-leaf cottonwood and willow in several locations in Colorado during 2012.
A localized outbreak of a flea beetle was detected in narrow-leaf cottonwood, *Populus angustifolia*, in the lower Williams Creek drainage on the western slope of the Wet Mountains during early July 2012. Area affected was about five acres. Large numbers of blue-black larvae were found feeding and skeletonizing the undersides of the foliage. A second area of skeletonizing of narrow-leaf cottonwood, encompassing about one acre, halfway between Villa Grove and Bonanza in the Keiber Creek Basin, was detected in mid-July. In both areas, feeding damage was confined to the mid and lower crowns of affected trees and caused a red brown discoloration of the foliage. The insect has been identified as a flea beetle of the genus *Altica* (Coleoptera: Chrysomelidae). In early August 2012 heavy defoliation of riparian Scouler's Willow, *Salix scouleriana*, was observed along the Herman Gulch hiking trail, northwest of Bakerville, CO (Clear Creek Co) on the Arapahoe National Forest. Large numbers of brightly colored leaf beetles were associated with the defoliation. The insect was identified as *Chrysomela aeneicollis* (Schaeffer). Areas of what appeared to be early fall coloration were noted in several stands of narrow-leaf cottonwood in the lower Big Thompson River Canyon during an aerial survey conducted in mid-August 2012. Subsequent ground checks indicated that the foliage of affected trees had suffered moderate to heavy damage by a leaf miner. Damage has been tentatively identified as being caused by poplar blackmine beetle, *Zeugophora scutellaris* Suffrain (Coleoptera: Megalopodidae). No life stages of the insect were found at the time of the detection of damage. Additional aerial and ground surveys detected damage in narrow-leaf cottonwood stands in the lower Cache la Poudre River Basin and in lower Rist Canyon, immediately

south of the Cache la Poudre River. During the aerial forest health survey, nine areas totaling 40 acres were mapped in the lower Big Thompson Canyon and twelve areas with a total of 70 acres were mapped in the lower Cache la Poudre Basin. Ground surveys indicated that damage was considerably more extensive than what was aerially visible and within the infested areas, about 70-80% of the leaves were damaged

It takes Two to Tango, but many more to dance! Forest health educational resources that transcend agency and geographical boundaries: The Bugwood Center (www.bugwood.org)

G. Keith Douce, David Moorhead, Charles T. Bargeron and Joe LaForest
The Bugwood Center for Invasive Species & Ecosystem Health, The University of Georgia, Tifton, GA USA

The Center for Invasive Species & Ecosystem Health's [aka: The Bugwood Center] mission is to serve a lead role in development, consolidation and dissemination of information and programs focused on invasive species, forest health, natural resource and agricultural management through technology development, program implementation, training, applied research and public awareness at the state, regional, national and international levels. Bugwood Center personnel develop and carry-out educational programs as well as work with and support educational needs of other educators, practitioners and others through hosting 30 websites on a wide-array of topics that received over 250 million hits and served information to over 9 million users during 2011. The Bugwood Center hosts multiple information technology tools that can be used by scientists, educators, and practitioners around the world to support their programs and needs. The Bugwood Center information technology systems/tools are database-driven, fully-integrated, and are widely used by others who also help build them through collaboration.

Mobile apps that can synergize forest health and invasive species education efforts (http://apps.bugwood.org)

G. Keith Douce, David Moorhead, Charles T. Bargeron and Joe LaForest
The Bugwood Center for Invasive Species & Ecosystem Health, The University of Georgia, Tifton, GA USA

Bugwood Apps are available for iPhone, iPad and Android systems and enable users to have access to identification information and to report sightings of invasive species from their smartphone. Reports include images, are georeferenced and are incorporated into the EDDMapS mapping system (www.eddmaps.org). Established EDDMapS protocols are used for verification or reports, follow-ups as necessary and subsequent access/viewing of report data by the public. EDDMapS combines data from other databases and organizations as well as volunteer observations to create a national network of shared invasive species distribution data. EDDMapS has over 1.9 million records and is being used in 40 states and in three Canadian provinces.

Epidemiological Assessment of Jeffrey Pine Beetle Population Dynamics within the Lake Tahoe Basin

Joel M. Egan[1], J. McLean Sloughter[2], Tamre Cardoso[3], Patrick Trainor[2], David Fournier[4], Hugh Safford[5], and John Wenz[1]
[1]Forest Health Protection, USDA Forest Service
[2]Department of Mathematics, Seattle University
[3]TerraStat Consulting Group
[4]Lake Tahoe Basin Management Unit, USDA Forest Service
[5]Pacific Southwest Region, USDA Forest Service

Multiple years of below average precipitation and suitable stand conditions have led to frequent Jeffrey pine beetle (*Dendroctonus jeffreyi* Hopkins) (JPB) outbreaks within the Lake Tahoe Basin over the past century. These outbreaks are temporally correlated with overall drought conditions. From the 1960s to 2013, outbreaks have occurred at a rate of once per decade within the Basin. These outbreaks are typically limited in spatial extent and severity or at incipient population levels. Only two outbreaks have been documented to exceed incipient population levels and progressed to extensive epidemics in the past 100 years. Assessments epidemic population dynamics have been documented for other species such as the mountain pine beetle (*Dendroctonus ponderosae* Hopkins) in lodgepole pine ecosystems. This work documents similar population dynamics states at an annual basis for JPB species that have not been studied to-date.

Census data were collected on every tree within a 60-acre study unit within the Lake Tahoe Basin from 1991-1996 during an extensive JPB outbreak. Measurements included tree species, JPB attack status, stem diameter, and geospatial location. Population dynamics varied by year and common characteristics were noted for incipient (1991), transition from incipient to epidemic (1992), epidemic (1993 and 1994), and post-epidemic (1995 and 1996) outbreak stages. Additionally, probability of tree mortality was modeled for individual variables with probit regression procedures. The typical characteristics for each outbreak stage and predictive modeling results are presented by category.

The rate of mortality (stems killed in current year relative to prior year) increased from incipient through epidemic outbreak stages and decreased in conjunction with above average precipitation that occurred in 1995. Mortality levels at incipient stage were limited as 84 of 10,465 total stems were killed by JPBs within the study site. The subsequent year tree mortality increased 8.3-fold when the outbreak transitioned from incipient to an epidemic outbreak stage. The epidemic stages had smaller increases of 1.2 to 1.7-fold and post-epidemic stages had 2-fold reductions until populations returned to endemic levels. Total mortality through all stages included 4,580 trees killed out of 10,465 or a 44% mortality rate.

The size of Jeffrey pine stems attacked varied by outbreak stage and was assessed within 1-acre units where stems were challenged with beetle populations. During incipient and incipient-epidemic transition stage, JPB-caused mortality occurred primarily in stems $\leq$ 20" diameter at 4.5 feet in height. Mortality progressed into larger diameter stems during the epidemic stage as populations increased and drought conditions persisted. In 1994, during the peak of the epidemic stage, JPB-caused mortality was significantly skewed away from 5-10" diameter classes indicating a distinct preference for large-diameter stems. During the following post-epidemic years, JPBs primarily caused mortality in ≤ 20" DBH stems as occurred in the incipient outbreak stage.

The spatial distance from nearest brood tree to trees successfully mass-attacked by JPBs varied by outbreak stage. During the incipient stage JPBs advanced into trees within approx. 120 feet of brood trees or dispersed further from brood trees and started new mortality centers. This proximity of successfully attacked stems to brood trees decreased in distance to within 60 feet of brood trees during the epidemic years. The distance increased again and beetles appeared to disperse further from brood trees in conjunction with the above average precipitation during the first post-epidemic year when populations started to decline

The degree of clustering gradually increased, peaked, and then decreased through this outbreak. The degree of mortality clustering transitioned from small clusters (< 4 stems/cluster) and individual trees within the incipient stage to moderate-sized clusters when the outbreak transitioned to an epidemic (2-49 stems/cluster). Clustering was greater in epidemic stages where large aggregations (> 50 stems/cluster) were the most common spatial pattern of mortality. The largest cluster was observed during the peak epidemic year (1994) and had a group of approximately 500 stems killed. During post-epidemic stages, clustering was reduced and was similar to the year when transition to epidemic occurred (2-49 stems/cluster).

Variables that were the most important for tree-level probability of mortality predictions, listed in order of importance, were: 1) bark beetle population pressure (defined as basal area of stems that were infested the year prior within a ¼-acre neighborhood), 2) minimum linear distance to nearest brood tree successfully attacked the prior year, 3) basal area within ¼-acre neighborhood, and 4) stem diameter. Interestingly, basal area within ¼-acre neighborhood reconstructed to pre-outbreak levels in 1991, prior to tree mortality, was a better predictor than basal area that is adjusted annually for mortality. This suggests the importance of pre-outbreak stand structure (microclimate and/or competition effects that for individual tree mortality.

Overall, predicting individual tree mortality was difficult in the incipient stage when mortality levels were limited and the environment largely determined mortality locations. Modeling improved when the outbreak transitioned to and throughout the epidemic stage as mortality levels increased and spatial parameters (distance to nearest brood tree and bark beetle population pressure) enhanced predictions. These results indicate that it is difficult to predict exactly where JPB-caused mortality will originate; however, predictions are reasonable once there is a transition from environmental determinism to self-focusing beetle population dynamic determinalist as spatial dynamics influence probability of mortality within the transition to epidemic and epidemic years. During post-epidemic stages predictions were difficult due to limited mortality and a change in the spatial dynamics as beetles dispersed during the first year of population decline.

Effects of Fuels Treatments on Bark Beetle Activity in Ponderosa-Jeffrey Pine Forests

Christopher J. Fettig
USFS, Pacific Southwest Research Station, Davis, CA

Large and severe wildfires in the western U.S., and particularly in California, have aroused public concern and manifested the need for well-designed treatments to reduce their extent and severity. Creating more fire-resilient forests generally requires treatment of surface and ladder fuels; reductions in crown density; and maintenance of large-diameter trees. To that end, a combination of thinning and prescribed fire has been shown to be highly effective for reducing the severity of wildfires in ponderosa (*Pinus ponderosa*) and Jeffrey pine (*P. jeffreyi*) forests. Both thinning and the application of prescribed fire may influence the amount and distribution of bark beetle-caused tree mortality at various spatial and temporal scales. For example, the health and vigor of residual trees; the size, distribution and abundance of preferred hosts; and the physical environment within forest stands may be impacted. Furthermore, tree volatiles released during fuels treatments, including monoterpenes, are known to influence the physiology and behavior of bark beetles and colonization rates of trees by bark beetles in ponderosa pine forests. I evaluate the responses of bark beetles (several species) to fuel reduction treatments over a 10-yr period at Blacks Mountain Experimental Forest, California. Results suggest that treatments designed to increase the resiliency of ponderosa pine forests to wildfire can be implemented without significantly increasing levels of bark beetle-caused tree mortality in the pine component.

Development of SPLAT™Verb

Christopher J. Fettig[1], A. Steven Munson[2] and Agenor Mafra-Neto[3]
[1]USFS, Pacific Southwest Research Station, Davis, CA
[2]USFS, Forest Health Protection, Ogden, UT
[3]ISCA Technologies Inc., Riverside, CA

Recent outbreaks of mountain pine beetle (*Dendroctonus ponderosae*) have been severe, long-lasting and well-documented. Management tactics include silvicultural treatments that reduce stand density (thinning) and presumably host susceptibility; sanitation harvests that remove infested trees; applications of insecticides to protect individual trees; and applications of semiochemicals including attractants deployed in trap-out, trap-tree, push-pull or concentration approaches and inhibitors used to disrupt colonization of individual trees or small-scale stands. Verbenone (4,6,6-trimethylbicyclo[3.1.1]hept-3-en-2-one) is an antiaggregation pheromone of mountain pine beetle, western pine beetle (*D. brevicomis*), and southern pine beetle (*D. frontalis*), and is produced by auto-oxidation of the host monoterpene α-pinene via the intermediary compounds *cis*- and *trans*-verbenol, by the beetles themselves, and/or through degradation of host tissues. Because of its behavioral activity, as demonstrated in numerous bioassays, verbenone has been evaluated as a tool for mitigating coniferous tree mortality due to bark beetle infestations. Results have been favorable, but inconsistent. Today, several pouch and flake formulations are registered by the U.S. Environmental Protection Agency (EPA) and used in the western U.S. In recent years, a Specialized Pheromone & Lure Application Technology (SPLAT™; ISCA Technologies Inc., Riverside, CA) has been developed that provides a long-lasting, controlled-release formulation to dispense semiochemicals, and has many desirable characteristics for use as a tree protection tool. In

2011, we first began evaluating SPLAT™ formulated with verbenone (now "SPLAT™Verb") for protecting individual lodgepole pines (*Pinus contorta*) from mortality attributed to mountain pine beetle. We discuss the results of this and subsequent research that demonstrated efficacy in both individual tree and small-scale plot (0.4-ha) studies. A registration application for SPLAT™Verb has been submitted to EPA and is currently under review.

Balsam woolly adelgid-caused fir decline across the western US: A method for assessing infestation severity and determining the role of environmental variability on ecosystem risk

K. Hrinkevich[1], R.A. Progar[2], L. Spiegel[2], L. Lazarus[3], L. Pederson[4], K. Chadwick[5], D. Carlson[6], B. Schaupp[7], C. Snyder[8], J. Marshall[9]
[1]Oregon State University, Corvallis, OR
[2]USFS, Pacific Northwest Research Station, La Grande, OR
[3]USFS, Forest Health Protection, Boise, ID
[4]USFS, Forest Health Protection, Coeur d'Alene, ID
[5]USFS, Forest Health Protection, Sandy, OR
[6]USFS, Forest Health Protection, Wenatchee, WA
[7]USFS, Forest Health Protection, Central Point, OR
[8]USFS, Forest Health Protection, Redding, CA
[9]CA Department of Forestry and Fire Protection, Ukiah, CA

The balsam woolly adelgid (*Adelges piceae*) (BWA) is an invasive species affecting true firs in North America that arrived from Europe in the early 1900's. Originally observed in eastern Canada, it first appeared in the western US around the 1930s in California and has since spread northeastward through Oregon, Washington, Idaho and Montana. BWA is a difficult pest to manage because of its highly varied behavior across species and habitat types. Some infestations can result in up to 90% tree mortality in under a decade, while others can persist for more than 40 years without causing significant losses. Regardless, once introduced, BWA appears to remain in a stand indefinitely, cycling through endemic and epidemic population phases as long as available hosts remain. BWA symptoms include crown and branch deformities, dieback and ultimately death resulting from salivary injections by feeding larvae that inhibit normal growth and stimulate anatomical, structural and physiological changes in the host tissue. Infestations of the main stem are often most damaging because they can quickly induce physiological drought in as little as 3 years. Crown attacks, characterized by gouting, can persist for decades before causing enough damage to result in tree mortality and often trees recover from these infestations given a period of BWA population decline.

Although BWA research in the Pacific Northwest has been ongoing since the 1960s, there are still questions about the susceptibility of different tree species and individual trees within a stand, as well as the role of environmental and climatic variability on BWA damage, thus there is difficulty determining how best to manage for and mitigate the ecological effects caused by this invasive pest. This study was designed to sample BWA-related tree decline across the species' range in the western US to determine how habitat variability and microclimatic differences influence infestation patterns and damage severity. We aim to develop a method of quantifying BWA severity that can be used to model risk across diverse environments and aid in prioritizing management decisions.

In 2012 we established 58 long-term BWA monitoring sites across the western US that included the installation of microclimate stations to record biologically-relevant variables at hour intervals throughout the year. At each site we recorded all BWA damage and classified symptoms by combining a number of previously used methodologies that allowed us to develop standardized damage assessments. We also recorded all environmental and stand information known to influence BWA population dynamics. We expect to continue monitoring and reassessing sites annually for three years to evaluate differences in BWA severity within and between sites over this time period to determine the major factors influencing susceptibility and ecosystem risk.

Effect of the first recorded Douglas-fir tussock moth, *Orgyia pseudotsugata*, outbreak on white fir in southern California

Michael Jones[1], Tom W. Coleman[2], Andrew D. Graves[3], Meghan Woods[4], Mary Louise Flint[5], and Steven J. Seybold[6]

[1]University of California, Department of Entomology, Davis, CA
[2]USDA FS, Forest Health Protection, San Bernardino, CA
[3]USDA FS, Forest Health Protection, Albuquerque, NM
[4]USDA FS, Forest Health Monitoring, Davis, CA
[5]Department of Entomology and Statewide Integrated Pest Management, University of California, Davis, CA
[6]USDA FS Research, Pacific Southwest Research Station, Davis, CA

The Douglas-fir tussock moth, *Orgyia pseudotsugata* McDunnough (Lepidoptera: Erebidae) is a native defoliator found throughout western North America, but no outbreak was ever detected in southern California until 2008 to 2011. We assessed the forest stand characteristics, level of defoliation, and tree mortality associated with the Douglas-fir tussock moth outbreak. These data were compared to forest stands dominated by white fir outside the outbreak. Forest stand measurements collected in this study were incorporated in the USDA FHTET Insect and Disease Risk Model to predict the basal area loss from future Douglas-fir tussock moth outbreaks. Total stand density was significantly higher (22%) in non-outbreak stands than in outbreak stands. However, outbreak stands had significantly greater dead white fir density (70%) and dead white fir basal area (32%) when compared to non-outbreak stands. Mean defoliation of white fir from the Douglas-fir tussock moth was 39% in the outbreak stands. In the outbreak stands, 62% of all the dead white fir was associated with Douglas-fir tussock moth defoliation. White fir mortality was highest (98%) when complete defoliation occurred. White fir basal area killed by the fir engraver, *Scolytus ventralis* LeConte (Coleoptera: Scolytinae), in non-outbreak stands was 1.2x greater when compared to outbreak stands. A total of 9,577 ha were predicted to be at risk to basal area loss from Douglas-fir tussock moth outbreaks and only 744 ha were predicted to be at high-risk in southern California. Changes in forest management objectives, land-use changes, and fire suppression policies likely increased the density of Douglas-fir tussock moth's host, leading to population outbreaks.

Comparing ADS Techniques – Grid vs. Contour Flying

Chad W. Nelson
USDA Forest Health Protection - Boise Field Office

Aerial Detection Surveys (ADS) have been conducted on regular basis for sixty years and are believed to still be the most cost effective way of tracking forest disturbance on a landscape scale. ADS missions are typically conducted using contour and grid flight patterns. Contour flights follow well-defined terrain like rivers, streams, and/or ridge. By contrast grid flights are flown in a straight line, often in a cardinal direction on pre-determined flight path in a back and forth pattern. In Forest Service Regions 1 and 4, the historical method has been a contour flight pattern. In 2012, 3-mile grid patterns were dominant. This poster examines the differences between contour and grid flight to collect ADS data. Acreage of mortality and defoliation, tree fader counts, and hours of flight/observer time were evaluated for each flight pattern.

Grid flights may be a more efficient method of flying most forested lands. However, the grid pattern may result in observed mortality being lumped into larger polygons, thus over-estimating the affected acreage and number of faders. Contour flights allow flexibility for timely "second looks" to confirm/refine damage estimates and location, possibly increasing the precision of both. Differences in safety risk between the two patterns are unclear. Total observer exposure time was about the same between the grid and contour patterns. However, the pilot's and single observer exposure was nearly doubled by the contour method. In areas of high mortality or defoliation, a 2-mile grid pattern may be utilized to more effectively map infested areas. This may affect total aircraft costs and observer time to sufficiently capture insect and disease activity on our Nation's Forest. Overall grid flights are a timelier and cost effective way of surveying large tracts of forested lands, but some precision may be compromised.

New range of California fivespined Ips in Washington State and the Columbia River Gorge in Oregon

Glenn R. Kohler[1], Todd A. Murray[2] & Elizabeth A. Willhite[3]
[1] Washington Dept. of Natural Resources, Olympia, WA;
[2] Washington State University Extension, Stevenson, WA;
[3] USDA Forest Service, Sandy, OR

From 2010 to 2012, outbreaks of California fivespined Ips (CFI) have occurred on both banks of the Columbia River near White Salmon, Washington and Hood River, Oregon. These outbreaks have resulted in unusually high levels of mortality in ponderosa pine. The Washington State Department of Natural Resources, Washington State University Extension, the US Forest Service, and several private landowners have cooperated on this study to monitor the distribution and flight periods of CFI. CFI populations were monitored using pheromone-baited funnel traps at 18 sites in Washington and Oregon. High numbers of CFI were collected along the Columbia River from Rowena, OR west to Vancouver, WA. Low numbers of CFI were collected as far north as Ft. Lewis and Trout Lake in Washington. The new range of CFI includes 2 counties in Oregon and 7 counties in Washington.

Elution of MCH Flakes in Three Stand Densities

Laura Lazarus, Andrew Graves, Phil Mocettini

Methylcyclohexenone (MCH), a beetle-produced compound, can be effective in limiting damage to Douglas-fir by the Douglas-fir beetle. Bubblecaps are the most common elution devices deployed for dissemination of MCH, but aerial applications of plastic laminate flakes may be useful in areas where it is dangerous for foot travel because of wildfire damage, blow downs, steep terrain, and avalanche conditions common in mountainous terrain. Certain areas of treatment may require less flakes than others based upon meteorological differences within stands, however, little is known about the impacts of stand characteristics on the elution rate of MCH flakes applied directly to the ground. Elution rates of MCH flakes were compared under three different stand densities on the Sawtooth National Forest, Idaho from June to August, 2012. No significant statistical differences were found among elution rates in the three stand densities. Therefore, stand density need not be a consideration while planning MCH flake dosage rates during aerial applications.

Field testing wing traps and pheromone lures for *Neodiprion* sp.

Chris Looney[1], Olle Anderbrant[2], Lia Spiegel[3], David R. Smith[4], Kathy Sheehan[5], Glenn Kohler[6], Sandra Kegley[7], Erik Hedenström[8], Darci Carlson[9], Fredrik Andersson[8]
[1]Washington State Dept. of Agriculture, Olympia, WA
[2]Lund University, Lund, Sweden
[3]USFS Forest Health Protection, La Grande, OR
[4]USDA Systematic Entomology Laboratory, Washington D.C.
[5]USFS Forest Health Protection, Portland, OR
[6]Washington State Dept. of Natural Resources, Olympia, WA
[7]USFS Forest Health Protection, Coeur d'Alene, ID
[8]Mid Sweden University, Sundsvall, Sweden
[9]USFS Forest Health Protection, Wenatchee, WA

Sawflies of the genus *Neodiprion* are obligate Pinaceae feeders, and some species are occasional or perennial defoliating pests in managed forests. The genus is most diverse in North America, with 34 described native species and the introduced European congener, *N. sertifer*. Although *Neodiprion* species can be pestiferous, there are relatively few mechanisms available for monitoring pest populations.

Traps baited with pheromone lures are commonly used to detect pest insects (e.g. *Lymantria dispar*, *Popillia japonica*), and an effective lure based on female sex pheromones has been developed for *Neodiprion sertifer*, a European species that is a frequent pest in managed forests and nursery production. This project tested two pheromone formulations based on the main components of the female *Neodiprion* sex pheromone, SSS-diprionyl acetate and SSS-diprionyl propanoate. Two pairs of wing traps baited with each lure were installed at eight locations across Washington, Oregon, and Idaho. Traps were generally installed in May, and maintained through October or November. Lures were replaced in mid to late August.

Male *Neodiprion* were successfully trapped at all locations. The acetate lure captured more male *Neodiprion* than the propanoate lure, although differences were statistically significant at only two sites. While the lures and traps were effective, the difficulties of male *Neodiprion* taxonomy are a significant hurdle: no morphological characters are known that allow identification of North American male *Neodiprion* to species. Males collected from all sites are being COI barcoded to see if molecular techniques will provide any insights, and pheromones will be extracted from females reared from trapping sites to explore species-specific pheromone composition. If males prove to be identifiable or more species-specific lures can be developed, pheromone lure trapping holds promise for monitoring *Neodiprion* species when conditions warrant.

Buprestid biosurveillance using *Cerceris californica*: preliminary results from Washington State.

Chris Looney, Warren Hellman
Washington State Department of Agriculture, Olympia, WA

The introduction and rapid spread of the emerald ash borer (*Agrilus planipennis*) in eastern North America emphasizes the importance of early detection of buprestids. Among the hurdles to buprestid survey are limited taxa-specific semiochemical or mechanical survey methods. Most surveys rely on sticky panel traps baited with a plant-volatile lure; these traps often have excessive by-catch of non-target species. Biosurveillance with the native wasp *Cerceris fumipennis* (Hymenoptera: Crabronidae) has proven to be an alternative innovative and effective tool for sampling local buprestid communities in eastern states. This predatory wasp commonly nests in large colonies in baseball diamonds and vacant lots, and captures a broad array of buprestid prey (over 110 recorded species), including the economically important genus *Agrilus*. A sister species in western North America, *Cerceris californica*, exhibits similar buprestid foraging behavior, with 29 recorded prey species. This project is adapting the eastern sampling methodology to *C. californica* in Washington State, to examine the potential utility of this survey method to complement standard detection activities for *A. planipennis* and another invasive congener, *A. auroguttatus*.

Beginning in early July, 186 ball fields were surveyed in eastern and western Washington. Seven *C. californica* colonies were detected, located in the cities of Yakima, Wenatchee, or Walla Walla. Nest density ranged from 1-24 nests, with only four sites robust enough (≥15 wasps) to support monitoring. Nest monitoring was conducted from mid-July through August. Buprestids were surveyed by retrieving paralyzed beetles from *C. californica* females returning to the nest. This is accomplished primarily by capturing prey-laden females with a net as they enter the nest area. Plastic collars were also placed over nest entrances, which impeded females entering with prey and provided more time to collect beetles. Thirty-six beetles were retrieved over 18 days of active monitoring.

The percentage of potential sites occupied by *C. californica* observed in this study (3.7%) is much lower than reports for *C. fumipennis* in eastern states (22%); 9% of eastern nest sites were robust enough for effective biosurveillance, compared with the 2.1% observed here. Only 36 buprestids were collected in this study, comprising four species. One species is a new state record for Washington, and three of the species are new prey records for *C. californica*. Beetle weights ranged from 0.0052g to 0.0523g. *Agrilus* *planipenis* can weigh between 0.02 and 0.046g, within the range of these observed catches. While *C. californica* appears to be capable of capturing beetles within the size and weight range of target species, the paucity of nest sites may limit the effectiveness of biosurveillance in Washington. Activities planned for spring and summer of 2013 include surveying more sites to see if *C. californica* is more readily found in other locations (e.g. sandy roads), conducting earlier monitoring to more fully explore the wasp's phenology, and side-by-side comparison of standard "purple prism" traps with monitored *Cerceris* nests.

Digital access to the Western Forest Insect Collection bark beetles (Curculionidae: Scolytinae) housed at the Oregon State Arthropod Collection.

C. J. Marshall & J. L. Hayes[1]
Oregon State University, Corvallis, OR
[1]U.S. Forest Service-Pacific Southwest Research Station, Albany, CA

The Western Forest Insect Collection (WFIC) and the data records associated with it are a little-known resource built up over many generations by the USFS that today reside at the Oregon State Arthropod Collection (OSAC) at the Oregon State University in Corvallis, Oregon. Several attempts have been made over the years to make this resource more accessible to the researchers and the general public -- but this most recent attempt integrates several novel elements which were previously non-existant; namely the ability to see digital images of the actual specimens and hopkins cards as well as the ability to interact with the database record through comments or for registered users by editing the actual data record. In essence it allows a disparate user group - interested in this valuable resource - to not only view the data, but to assist in the creation/curation/management of the database. This system, built using Drupal, a well known open source Content Management System, that runs on PHP and MySQL provides a framework in which the historical information associated with the WFIC can be stored along with corresponding metadata, while also allowing novel information (including updated nomenclatural data and/or re-interpretations of records) to be included alongside the historical data.

Mountain pine beetle-mite communities in ponderosa and lodgepole pine forests in the Colorado Front Range

Javier Mercado
Colorado State University, Fort Collins, CO 80524

The mountain pine beetle's (MPB) phoretic mite community was compared in lodgepole and ponderosa pine in the Colorado's Front Range. Two mite species not previously documented from this beetle were found. Comparing the mite communities associated with beetles from both host trees did not show significant differences. Ophiostomatoid fungi were isolated from three mite genera. Preliminary results show that *Tarsonemus* sp. and *Proctolaelaps* sp. carry *Grosmannia clavigera* and *Ophiostoma montium*, two fungal associates of the MPB. However, *Trichouropoda* sp. only carried *G. clavigera*. Symbiotic mites may be playing a key role in vectoring these fungi.

Inundative Release of Flea Beetles as a Biological "Herbicide" on Postfire Leafy Spurge

R. Progar[1], S. Sing[2], J. Milan[3], C.L. Jorgensen[4], and M. Rinella[5]
[1]USFS, Pacific Northwest Research Station, LaGrande, Oregon; [2]USFS, Rocky Mountain Research Station. Bozeman, Montana; [3]BLM, Lower Snake River District, Boise, Idaho; [4]Forest Health Protection Field Office, Boise, Idaho; [5]USDA ARS Miles City, MT,

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 complex, 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 post-fire burned areas where populations of leafy spurge are resurging due to the lack of competition or biological control agents. Postfire conditions can create ideal habitat for certain plants. Fire only removes the above-ground parts of leafy spurge. Some leafy spurge is able to survive fire if the fire is not hot enough to kill the underground roots. Fire – whether wild or controlled, provides a burst of nutrients that stimulates growth in the years immediately following fire. This study assessed leafy spurge and associated vegetation responses to inundative releases of 50 beetles per spurge flowering stem over two consecutive years. A response in nontarget grass, forbs or shrubs was not observed during the course of this study. Inundative releases of *Aphthona* flea beetles reduced seedling density by nearly 80%. Leafy spurge cover was reduced by more than 50% from 20010-2012; % flowering stems was reduced by 65%; average number of leafy spurge crowns was reduced by 43% per m ^{2}; average number of leafy spurge stems was reduced by 43% per m^2; average stem length was reduced by 26% from 2010-2012; average leafy spurge biomass per m^2 was reduced by 68% from 2010 to 2012.

Population Densities and Tree Diameter Effects Associated with Verbenone Treatments to Reduce Mountain Pine Beetle *(Dendroctonus ponderosae)* -Caused Mortality of Lodgepole Pine (*Pinus contorta* var *latifolia)*

R. A. Progar[1], D. C. Blackford[2], D. R. Cluck[3], S. Costello[4], L. B. Dunning[5], T. Eager[6], C. L. Jorgensen[7], A. S. Munson[8], B. Steed[9], and M. J. Rinella[10]
[1]USFS, Pacific Northwest Research Station, La Grande, Oregon 97850, [2]USFS, Forest Health Protection, Ogden, Utah 84403, [3]USFS, Forest Health Protection , Susanville, CA 96130, [4]USFS, Forest Health Protection, Lakewood, Colorado 80225, [5] USFS, Forest Health Protection, Ogden, Utah 84403, [6] USFS, Forest Health Protection, Gunnison, Colorado 81230, [7] USFS, Forest Health Protection, Boise, Idaho 83709, [8] USFS, Forest Health Protection, Ogden, Utah 84403, [9] USFS, Forest Health Protection, Missoula, Montana 59807, [10]USDA-ARS, Livestock and Range Research Laboratory, 243 Fort Keogh Road, Miles City, MT 59301

Mountain pine beetle, *Dendroctonus ponderosae* Hopkins (Coleoptera: Curculionidae: Scolytinae), is among the primary causes of mature lodgepole pine, *Pinus contorta* variety *latifolia* mortality. Verbenone is the only antiaggregant semiochemical commercially available for reducing mountain pine beetle infestation of lodgepole pine. The success of verbenone treatments has varied greatly in previous studies

because of differences in study duration, beetle population size, tree size, or other factors. To determine the ability of verbenone to protect lodgepole pine over long-term mountain pine beetle outbreaks, we applied verbenone treatments annually for 3 to 7 yr at five western United States sites. At one site, an outbreak did not develop; at two sites, verbenone reduced lodgepole pine mortality in medium and large diameter at breast height trees, and at the remaining two sites verbenone was ineffective at reducing beetle infestation. Verbenone reduced mountain pine beetle infestation of lodgepole pine trees in treated areas when populations built gradually or when outbreaks in surrounding untreated forests were of moderate severity. Verbenone did not protect trees when mountain pine beetle populations rapidly increase.

Whitebark Pine Stand Conditions after Mountain Pine Beetle Outbreaks in Idaho, Wyoming and Montana

Kendra Schotzko[1], Stephen Cook[1], Carl Jørgensen[2], Sandy Kegley[3],
John Schwandt[3], Laura Lazarus[2], and Jim Hoffman[2]
[1]University of Idaho, Moscow, ID, [2]USFS Forest Health Protection, Boise, ID,
[3]USFS Forest Health Protection, Coeur d'Alene, ID

Whitebark pine (*Pinus albicaulis*) has a large natural range but is declining in the Intermountain West due to a combination of white pine blister rust (*Cronartium ribicola*), forest succession, and recent outbreaks of mountain pine beetle (*Dendroctonus ponderosae*). Our project aims to obtain information that will be used to make recommendations and set priorities regarding restoration of whitebark pine in central Idaho and adjacent areas in Wyoming and Montana. Areas where recent mountain pine beetle outbreaks have occurred were identified and sampled using variable radius plots for mature trees and fixed area plots for regeneration. Data collected included tree species, diameter at breast height, and various condition factors. During our first field season we visited 22 sites in mountain pine beetle affected areas and assessed the abundance and condition of mature trees and regeneration. We found substantial mortality of mature whitebark pine at the majority of sites measured, largely due to mountain pine beetle. We also found a decrease in whitebark pine regeneration relative to subalpine fir (*Abies lasiocarpa*) at most of the sites.

A Test of Verbenone and other Compounds to Protect Ponderosa Pine from Mountain Pine Beetle Attack

Nancy Sturdevant, Chris Hayes, Laura Lazarus and Sandy Kegley
Forest Health Protection, Region1/4
Missoula and Boise Field Offices

Verbenone has been tested alone or in combination with green-leaf volatiles to protect lodgepole and whitebark pine numerous times. Very little testing has occurred in ponderosa pine, however. The objective of this study was to test verbenone and other promising compounds in protecting ponderosa pine from mountain pine beetle attack. Single tree protection field experiments were conducted at three field locations in Montana and Idaho. In Idaho one site was selected. Sixty trees were selected and randomly assigned to either verbenone (two 7.5 g verbenone pouches) or control. At two Montana sites, 90 trees were selected at each site and treatments were randomly assigned. Treatments consisted of verbenone, compound C, a three component inhibitor mix, or a control. Mountain pine beetle pheromone baits were used to insure adequate beetle pressure for each individual tree treatment. At one site in Montana, there was high beetle pressure and a significant difference among beetle attack rates; both verbenone and compound C provided high levels of tree protection and the control had high mortality rates. Despite non-significant results at the other Montana site, verbenone had the largest number of trees not attacked and the fewest mass attacked trees, with only 3 trees killed by MPB. There was not enough beetle pressure at the Idaho site to analyze these data.

Mountain Pine Beetle Size and Lipid Content Influenced by Two Pines and their Host Defense Strategies Against Beetle Attack

Daniel R. West[1], Jenny S. Briggs[2], William R. Jacobi[1]
[1]Colorado State University, Dept. Bioagricultural Sciences and Pest Management, Fort Collins, CO
[2]US Geological Survey, Geosciences and Environmental Change Science Center, Lakewood, CO

Mountain pine beetle *(Dendroctonus ponderosae* Hopkins; MPB) populations increased in 2007 along eastern slopes of the Front Range, in north-central Colorado, and caused significant lodgepole pine mortality. Land managers were concerned that ponderosa pine at lower elevations of the Front Range would also be killed. To study the potential for ponderosa pine to be attacked, we conducted choice experiments of MPB host selection between lodgepole and ponderosa pines while controlling natal host species. Overall, MPB selected ponderosa pine cut logs 2:1 over lodgepole pine. We measured the size of MPB brood produced from our choice experiments and found MPB from ponderosa pines were larger than those from lodgepole pines (pronotum length + width/2; $p<0.0001$). Subsamples of beetles ($n=80$) from our choice treatments were analyzed for whole insect lipid content and composition differences via GC-FID. Lipids were extracted using 2:1 chloroform:methanol while eicosane was used as our internal standard. Lipid quantities were standardized by beetle fresh weight (mg). MPB fatty acid quantity was not different between natal hosts ($p=0.7$) or selected host combinations ($p=0.4$). These findings indicate that MPB from ponderosa pines are larger than those from lodgepole pine, though have no greater lipids per beetle size prior to flight.

Our choice experiments offered cut logs to beetles of a controlled natal species, which rendered the primary defenses of choice logs impotent. Hence, we conducted a constitutive oleoresin chemical and flow study comparing resin defenses from lodgepole and ponderosa pines. Paired lodgepole-ponderosa pines of the same diameter were sampled from the same stands under similar site conditions at 3 locations in the Front Range CO during peak MPB flight weeks. Resin was collected for 24 hrs on the north and south aspects of both host species at 1.4 m. No differences in oleoresin flow (weights) were detected between north and south aspects for either tree species. Ponderosa pines produced approximately 4x the oleoresin than lodgepole pines under similar stand and environmental conditions. Oleoresins from both species were chemically analyzed through GC-FID, using hexane as a solvent and eicosane as an internal standard. Lodgepole pines produced significantly more limonene ($p=0.02$), β-phellandrene ($p<0.0001$), and cymene ($p=0.001$) than ponderosa pines. These findings indicate that ponderosa pines produce four times as much mechanical defense against bark beetle attack compared to lodgepole pines, while lodgepole pines have greater chemical defenses (limonene) against bark beetle attack than ponderosa pines under similar stand and environmental conditions, though the ecological relevance of monoterpene concentrations against beetle attack is less known.

Mountain Pine Beetle Host Selection between Lodgepole and Ponderosa Pines in the Southern Rocky Mountains

Daniel R. West[1], Jenny S. Briggs[2], William R. Jacobi[1]
[1]Colorado State University, Dept. Bioagricultural Sciences and Pest Management, Fort Collins, CO
[2]US Geological Survey, Geosciences and Environmental Change Science Center, Lakewood, CO

In 2007, mountain pine beetle- *(Dendroctonus ponderosae* Hopkins; MPB) caused lodgepole pine mortality increased in northern Colorado on the east side of the Front Range Mountains. Land managers were concerned as to the susceptibility of ponderosa pine dominated stands. Prior to 2007, MPB-caused mortality was largely endemic along the Front Range in ponderosa pine stands. We used a field based approach to address the question: “Will mountain pine beetle-caused mortality in ponderosa pine be similar to that in lodgepole pine in the ecotone between the two species?” We surveyed 19 sites in the mixed conifer lodgepole-ponderosa ecotone along140 km of the northern Front Range (2440-2740 m elev.) where previous season mountain pine beetle activity was detected in several lodgepole pine trees. Each site contained a set of 3-0.20 ha (1/2 ac) monitoring plots containing 50% basal area of lodgepole pine and ponderosa pine. All MPB-caused mortality between 2004-2011 was recorded on each plot. We found no differences between lodgepole and ponderosa pine mortality for any year, though total mortality levels were different between years (curvilinear). Basal areas from the previous year’s MPB-caused ponderosa pine mortality, MPB-caused lodgepole pine mortality, and quantity of uninfested ponderosa pine host were significant predictors of the next year’s MPB-caused mortality in ponderosa pine. Only previous MPB-caused mortality in lodgepole pine and uninfested lodgepole pine levels were significant predictors of the next year’s lodgepole pine mortality. These findings indicate that MPB infested ponderosa pine from both lodgepole pine and ponderosa pine natal hosts, while lodgepole pines were infested from lodgepole pine natal hosts.

In 2010-11, we used controlled-field experiments and lab bioassays to directly assess: “Does the mountain pine beetle prefer ponderosa pine over lodgepole pine while the natal host species is controlled?” We controlled for MPB-natal host by attaching emergence cages to either naturally infested lodgepole pine or ponderosa pine at one site in 2010 and another site in 2011 (2590 to 2650 m). Newly emerged insects were funneled to choice arenas (n=12) where freshly cut logs of both hosts were replaced once a week for five weeks during peak adult emergence (120 choice logs/year). Choice logs were placed in cages to assess adult emergence, and then logs were peeled, and ovipositional galleries were counted and measured. MPB preferred ponderosa pine cut logs 2:1, even though significantly more insects entered the arenas from lodgepole pine natal host species. No differences in ovipositional gallery lengths or emerged brood per female were detected between host species. Host selection behavior in the absence of attraction pheromones was tested through behavioral bioassays comprising freshly cut phloem/bark units (32 cm^2) suspended in paraffin wax. Bark units from both pine hosts were offered within individual containers to MPB females that developed from either host (n=64 paired trials; 32 replicates from each natal host). Female MPB preferred ponderosa pine bark units over lodgepole pine bark units approx 2:1 in the behavioral bioassays. These findings indicate MPB prefers ponderosa pine over lodgepole pine when mechanical host defenses are debilitated (resin flow).

FIELD TRIPS

Wallace, ID

The historic town of Wallace, Idaho where we visited a mining museum, learned about the 1910 fires, famous Ed Pulaski, and the rich bordello history at a local pub.

Nursery

Forest Service nursery tour where we learned how seeds are extracted from cones, stored, sown, and grown; and an urban forestry hike on Tubbs Hill where we discussed root disease, non-native trees, and Fire Smart activities.

Northwest Museum of Arts & Culture

Spokane, Washington where we visited the Northwest Museum of Arts & Culture (MAC) to see the Douglas display (the botanist Douglas-fir is named after) and a Fire Lookout museum.

Group Photographs

Back: Bill Riel, Sandy Kegley, Danny Cluck, Kathy Sheehan, Pat Ciesla, Fred Hain
Front: Chris Fettig, Curtis Takahashi, Dan Owen, Carol Gibson, Ken Gibson, Cynthia Snyder

Back: Darek Czokajlo, Frank Sapio, Tim McConnell, Paul Oester, Dave Shaw, Rob Cruz
Front: Mary Reid, Mathias Kaiser, Karen Ripley, Les Koch, Andy Eglitis, Maylea Miller-Pierce

Back: Tom Eckberg, Dwight Scarbrough, Whitney Rehberg, Don Grosman, Steve Cook, Keith Douce
Front: Kim Johnson, Daniel Ryerson, Leanna Lachowsky, Chris Hayes, Von Helmuth, Wyatt Williams

Back: Celia Boone, Kendra Schotzko, Erin Clark, Kathy Bleiker, Stephen Burr, Dan West
Front: Eric Smith, Haydee Peralta, Javier E. Mercado, Richard Hofstetter, Elizabeth Graham, Stephani Sandoval

Back: Yasmin J. Cardoza, Jordan Burke, Jim Hanula, Bruce Thomson, Angie Ambourn, Rob Rabaglia
Front: Jesse Pfammatter, Seth Davis, Dianna Six, Tom Kolb, Amanda Grady, Chelsea Toone

Back: Nancy Sturdevant, Chad Nelson, Iral Ragenovich, Steve Munson, Danielle Reboletti
Front: Scott Sontag, Connie Mehmel, Andy Eglitis, Paul Zambino, Barbara Bentz, Ryan Bracewell

Back: Brytten Steed, Tom Eager, Andy Graves, Jim Ellenwood, David Wakarchuk
Front: Mike Johnson, Keith Sprengel, Colleen Keyes, Beth Willhite, Amy Gannon, Sky Stephens

Back: Laine Smith, Bill Sweeney, Bruce Hostetler, Nancy Grolke
Front: Bill Schaupp, Joel Egan, Carl Jorgensen, Gina Davis, Glenn Kohler, Darrell Ross

Back: Don Fowler, Ron Billings
Front: Jim Kruse, Dayle Bennett, Lia Spiegel, Darren Blackford, Tom Coleman, Stephen Nicholson

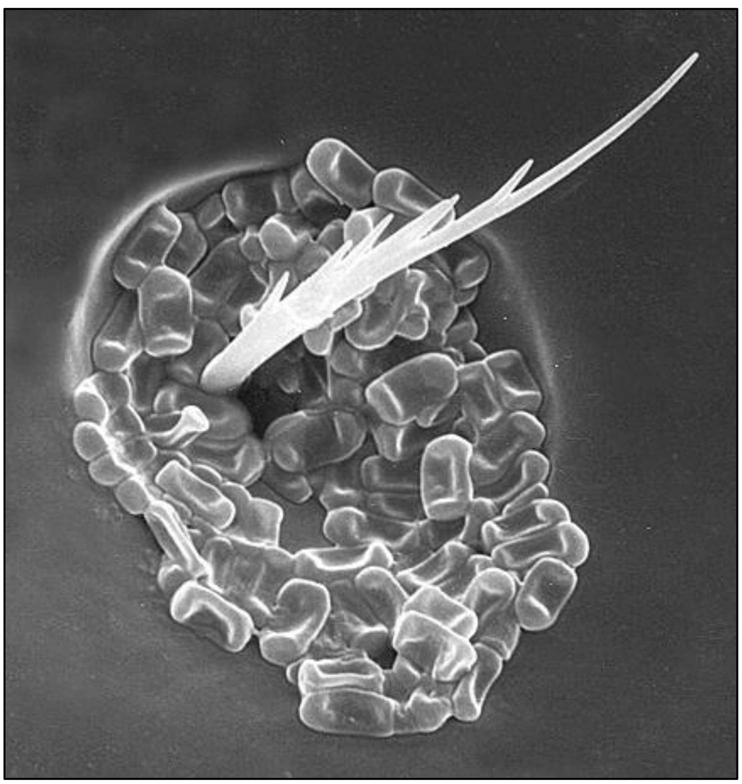
Back: Jim Vandygriff, John Schwandt, Marcus Jackson
Front: Arjan Meddens, Rob Flowers, Laura Lazarus, Beverly Bulaon

Photo Contest Winners

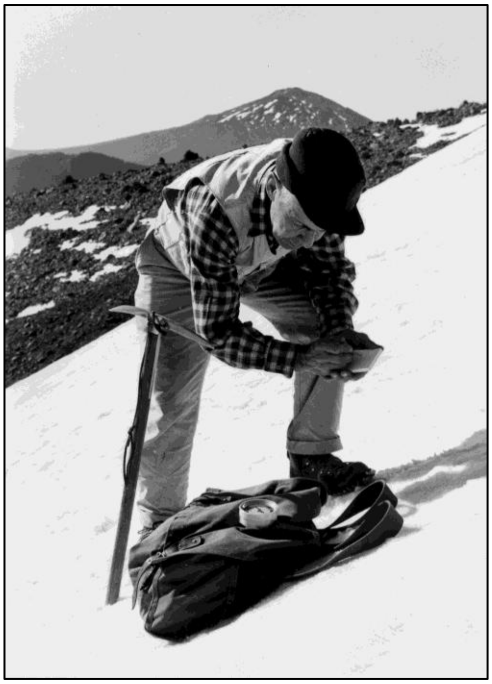
Forest Insect: Winner – Rob Flowers, Stink bug predation (shown here); Second Place – Ron Billings; Third Place - Nick Aflitto

Insect Damage: First Place – Ron Billings, SPB infestation on Turkey Hill (shown here); Second Place – Mal Furniss; Third Place – Ron Billings

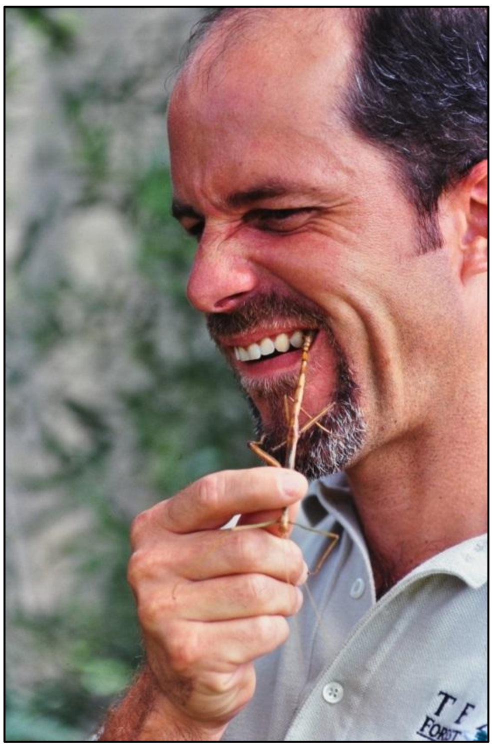
Series: First Place – Bill Ciesla, Stages in the life history of western tent caterpillar, *Malacosoma californicum* (shown here); Second Place – David Shaw, pine butterfly; Third Place – Bill Ciesla, *Pseudosphinx tertrio*



Other: First Place – Mal Furniss, Ascospores, *Ophiostoma ips* in pit on *Ips pini* elytron (shown here); Second Place – Sandy Kegley; Third Place – Dayle Bennett



Entomologist at Work: First Place – Mal Furniss, Robert L. Furniss, on South Sister Mtn recording elevation of a scolytid collection (shown here); Second Place – Ron Billings; Third Place – Mal Furniss



Humor: First Place – Ron Billings, Entomologist finds new use for giant walking stick (shown here); Second Place - Mal Furniss; Third Place – Ron Billings

Coeur d'Alene Forest Insect Laboratory — its Origin and History

Prepared for WFIWC 2013 Proceedings

By Malcolm Furniss[1]

The Coeur d'Alene Forest Insect Investigations Field Station, as it was known, got off to a shaky start. In 1915, its founder, James C. Evenden, was stationed with the Bureau of Entomology, Division of Forest Insect Investigations, in Missoula, MT. He had come there a year out of Oregon State College forestry school from a position as lookout on the Hood River Ranger District, Oregon. Things were not going well as will be recounted.

But, to put the picture into perspective requires a look back 25 years previously to the beginning of American Forest Entomology itself in 1890.

Andrew Hopkins

Through remarkable circumstances, Andrew Delmar Hopkins (1857-1948) (Fig. 1), a farmer educated in the county schools, was hired in 1890 as the state entomologist by the West Virginia University Agricultural Experiment Station (Furniss 2010). He spent that summer getting acquainted with insect problems throughout the state. On the 25th of August, Hopkins, accompanied by Charles F. Millspaugh, a medical doctor turned botanist, boarded the Baltimore & Ohio R.R. at Morgantown to follow-up on reports that valuable forests of spruce[2] in the Cheat Range of eastern West Virginia were being destroyed by some insect or disease. They reached Huttonsville at 6:30 P.M. on the 26th in driving rain which made the roads impassable. However, the morning of the 28th, "dawned bright and auspicious" and they proceeded by stage along the broad valley of Tygart's River to the base of the mountains, thence upward in elevation to the "spruce line" at an elevation of 3,425 feet. Two miles farther, they gained the summit of "Old White Top", the scene of the Civil War battle of Cheat Mountain.

Millspaugh noted that, at first, their view to the east and south disclosed normal-appearing forest extending to the hazy distance. "On turning, however, in our seats, what a change! The vast forests of the western ranges were brown in death, the gaunt trees stood like types of desolation ... ." Subsequent inquiry disclosed that the dying of trees had followed a severe drought in 1882 and lasted until five years before their visit to the area. The specific insect responsible is left somewhat in question. At the time, Hopkins had no knowledge of scolytids; however similar trouble was occurring elsewhere in pine which led to his studying the southern pine beetle, *Dendroctonus frontalis* (Zimmerman). His brilliant and comprehensive subsequent work related to the beetle thrust him into prominence and led him to specialize in the bark-beetle family, Scolytidae (now Scolytinae), especially the destructive genus *Dendroctonus*.

In 1902, he became the first Chief of the Division of Forest Insect Investigations, in the Bureau of Entomology, USDA, Washington, D.C. Hopkins divided the country into regions and began recruiting field personnel for each. Most of the forests and insect problems were in the west and he assigned Jesse Lee Webb to the Rocky Mountains and Harry E. Burke, a former classmate of Webb at Washington State

[1] For presentation by Sandra Kegley
[2] Red spruce, *Picea rubens* (Sarg.) is native to this area; he thought that it was black spruce as shown in his report: (Hopkins 1891),

College, to the "Pacific Slope" (Burke 1948). Web was the first person to receive a degree in forest entomology in America (West Virginia 1902). His first assignment was to the Black Hills, South Dakota (Fig. 2) where a vast outbreak of the Black Hills beetle (now the mountain pine beetle) was in its height and the scene of the first bark beetle control project in America.

Before long, an improbable person was to join Hopkins' staff rather by chance.

Josef Brunner

In 1908, Josef Brunner (Figs. 3) – an immigrant Bavarian with some training in European forestry - was living in Pine Grove, Montana as a big game hunter and outdoors writer. He noticed extensive killing of lodgepole pine by bark beetles in the Snowy Mountains while hunting and wrote (2 January 1909) to Chief Forester Gifford Pinchot in Washington, D.C. wanting to know "… the name of the little bug which makes the inner bark of freshly fallen trees (pine, spruce, fir) its primary breeding place and then attacks en masse nearby standing green trees? … the name is wanted for use in a magazine article into which I do not wish any mistake to find its way." The letter was forwarded to Hopkins, whose answer proved too complicated, as Brunner replied (6 February 1909): "Unspeakable names don't serve to popularize a subject ... German foresters solved the problem long ago by calling these various bugs just Der Barkenkafer (the bark beetle)."

The two men corresponded further and Brunner's interest in forest insects led Hopkins to hire him on 1 July 1909 as Agent and Expert at $1,200 per annum. (Furniss 2003).

In 1914, additional assistance was being sought at Missoula. James C. Evenden was about to enter the scene.

James C. Evenden (1889-1980)

Evenden (Fig. 4) grew up on a farm seven miles west of McMinnville, Oregon. In his 1979 oral history interview (Larson 1979), he was asked about his education: "I registered in the School of Forestry at the Oregon State Agricultural College. Having worked in saw mills and lumber camps, forestry seemed to be a field that I would enjoy. At that time, the college offered a two year sub-freshman course for non-high school graduates. I registered as a sub-freshman as I had not attended high school." Entomology was offered as a half semester course. After graduating in 1914, he got a job with the Forest Service:

> "I reported to Supervisor Sherrard in Portland who told me very briefly that I was to go to Lookout Mountain where I was to build a cabin on top of the mountain, with windows all around. This work would be under the supervision of Ranger Cooper who was in charge of the Parkdale Ranger Station. He told me I'd need a horse and a pack horse. I had no idea where Parkdale Ranger Station was and so I asked the clerk as I left Supervisor Sherrard's office and he advised me that the ranger station was about 11 miles from Hood River. With my small amount of money, I purchased a riding saddle and a sawbuck pack saddle from a pawn shop and took a night train to Hood River. There I hoped I would be able to buy a saddle horse and pack horse. Fortunately, in the morning I found a livery stable that had horses for sale. I purchased a nice riding horse for $40 and a lame pack horse for $15 --an expenditure which practically exhausted the small amount of money I had available. With my horses, I rode to Parkdale and reported to Ranger Cooper."

On 30 June 1914, Brunner wrote to Hopkins that the Civil Service list of persons who passed the test for the Entomological Ranger position included Evenden who was contacted subsequently for the job. Brunner wrote to Hopkins(6 July): "If Evenden ...takes the place of Fleming (who resigned) I hope he is city broke and does not make a fool of himself when he gets into town after being out in camp, like they all seem to do."

Evenden was appointed Entomological Ranger at $900 per annum on 1 October 1914 and told to report to Brunner. Evenden arrived in Missoula 6 October 1914 and proceeded to Clearwater. He recalled later (Larson 1979) his dismay upon arriving at the so-called winter camp two days later: "I found that the camp consisted of a 7 x 9-ft tent, some bedding rolled up in one corner, a fire ring of stones out in front with a frying pan and a few other cooking utensils, but no food to cook." He retreated to Potomac for the night and on the next day "rustled some old lumber, an old cooking stove with no legs, and a heating stove and returned to camp." Most of the items were given to him by townspeople. He thought he would have returned home if train fare was available, however, in a few days he and Entomological Ranger Albert Wagner had set up a rather comfortable camp with separate tents for cooking and sleeping. On 24 October 1914, Brunner wrote Hopkins: "Have just returned from a trip to Wagner's and Evenden's camp ... Evenden appears to be promising material and my fear that he might be rather a drag than a help in camp, I am glad to state, is entirely demolished."

Evenden gets a sub-station at Coeur d'Alene - 1915

Early in 1915, Evenden was being pressed to decide whether to stay with Bureau or to return to his position with the Forest Service in Oregon. Hopkins, who was well aware of Brunner's difficult personality and of Evenden's options regarding the Forest Service, devised a way out of the dilemma. As recalled by Evenden (Larson 1979): "My mind was finally made up by Dr. Hopkins who wrote to me saying that if I would stay with the Bureau, I could go to North Idaho (Coeur d'Alene) and establish a sub-station to the Missoula station. This offer appealed to me because it put me on my own so I decided to accept."

Evenden arrived in Coeur d'Alene in March 1915, remarking later that the city was "Vastly different than what it is today. No roads in the forest at all. The city was small. Transportation around the lake was by boat. Boats left in the morning and afternoon, no automobiles. It was mainly a lumbering town. There was a road between Coeur d'Alene and Wallace and Kellogg known as the Mullan Trail which was built by Captain Mullan."

"Being alone with no funds, all I had for a sub-station and an office was a room in a private home--a large room. I worked from that room, ate my meals at restaurants. My assignment was to establish the status of and the damage to the forests of northern Idaho by insects, to establish the seasonal histories of bark beetles, and to obtain the phenological records."

He worked on these assignments until May 1917, when he was granted leave to attend the Officers Reserve Training Camp at the Presidio, San Francisco, California and received a commission as a second lieutenant in the Officers Reserve Corp. Just as Evenden was preparing to leave, he got word that Brunner had been severed from employment in consequence of a disagreement with Hopkins (Furniss 2003) and he was directed to go to Missoula and take custody of records there.

Evenden became a Captain in command of "G" Co. 363rd infantry, 91st division, and went overseas in June 1918. He returned to Coeur d'Alene on June 16, 1919 as a scientific assistant with the Bureau of Entomology.

Early years of the Coeur d'Alene Forest Insect Station

The station consisted of a house on lower 7th Street (Fig. 4A), rented for ten dollars a month. He was assigned to study "all destructive forest insects, the extent of their damage, their potential control, and the importance of insects to the practice of forestry." The territory assigned to the Station included Regions one (Idaho, Montana) and four (Utah, Nevada) of the Forest Service. Evenden worked there alone until Henry Rust was hired in 1921.

Henry J. Rust (1878-1948) Henry (Figs. 5, 5A) was a keen observer, patient with detail, and a skilled photographer. He personally reared all insect material collected by him and others at the lab and kept detailed records, catalogs, and reports of the results, which were studies in themselves. Although he was not college-trained, he was assigned, because of his abilities, to study the biology of the pine engraver beetle and mortality of mountain pine beetle broods after bark was peeled from felled infested trees (Rust 1931, 1935). Rust was deeply interested in birds and mammals of northern Idaho. He published a masterful illustrated work involving 34 years of observations of the Pacific nighthawk (Fig. 6) on Tubbs Hill here in Coeur d'Alene (Rust 1947). His publication on the mammals of Idaho (Rust 1946) provides fascinating perspective on the status of numerous animals then. Examples are the Norway rat, first reported in Shoshone Co. in 1932. In February 1941, after breeding in the city garbage dump, two large invasions of the rat occurred in the north section of Coeur d'Alene over-running grocery stores, warehouses and homes. There followed a massive campaign to rid them. The last wolf that he saw was killed near Coeur d'Alene in 1905. A fisher was killed on the south shore of Coeur d'Alene Lake in 1893 and one was trapped on the Coeur d'Alene N.F. in 1916. Rust retired on disability in 1943.

Tom T. Terrell (1904-1985), a high school graduate, was hired next. He was launched unwittingly into a career in forest entomology in 1926 at age 22. He was reporting to work as a fire guard when, "At Wisdom (Montana), I got on the wrong Forest Service truck and ended up at a bark beetle control camp where I met Jim Evenden. Jim thought that I might be a good spotter (locating infested trees to be treated)."

In 1930, Terrell (Fig.7) made the first aerial survey of forest insect damage in the northern Rocky Mountains (Terrell 1977):

> "The first flight of the survey could not be called auspicious; it was to be over Yellowstone National Park (YNP) from a field at Livingston, Montana. I had maps of the Park but nothing for the 65 miles between Livingston and the Park. The pilot had a railroad folder that showed a line going straight south to the Park. Away we went and got lost in the Absaroka Mountains where we were caught in a violent rainstorm. The plane was a small open-cockpit biplane, the pilot in the rear and me up front. The engine went quiet! Then loud pounding behind me! I was about to dive over the side and pull the ripcord when I discovered that the pilot was pounding on the plane to get my attention. He got it. He wanted to know if I didn't think we ought to go back? He had cut the engine so he could talk to me. I most certainly agreed with him. I was scared stiff. We made it back to the field where Jim Evenden

was waiting. By that time the storm was real bad. The pilot taxied the plane up to the fence where we jumped out and with the help of Jim hung onto the plane and the fence to keep the plane on the ground until the storm let up. The pilot was Nick Mammer who later became a famous aviator in the region and one of the first mail and airline pilots in our area."

Terrell had vocational training and an inherent capacity to devise equipment and methods of investigation. For example, he flew weather bureau kites (Fig.7A) equipped with nets in an attempt to determine if the mountain pine beetle was dispersing across a clearing in the Big Hole Basin, Montana. In this instance only one scolytid was caught; it was not a mountain pine beetle. Throughout the years, Terrell was involved in numerous surveys, both on the ground and in the air, and in various control projects in YNP and national forests in the northern Rockies (Fig. 8). He remained with the laboratory throughout his career, retiring after the move to Missoula.

Reginald E. Balch (1894-1994) was another early employee at the Coeur d'Alene lab. He was born in England and immigrated to Canada at age 19. Following service during World War I and graduation from Syracuse University, he worked during 1928 – 1929 as a forest entomologist with the Coeur d'Alene lab. Thereafter he moved to Fredericton, New Brunswick, Canada, becoming Officer-in-Charge of the Forest Biology Laboratory and attracted much acclaim for his work. Relevant here, he worked during 1929 in southwestern YNP at Bechler River Ranger Station studying competently and in great detail a budworm on lodgepole pine. He concluded (Balch 1930) that it must be a variety of the eastern spruce budworm but known now as a distinct species, the sugar pine tortrix, *Choristoneura lambertiana* (Busck), infesting pines in much of the west.

During that single season, he described the insect's life stages, life history and habits, natural control (parasites, predators); explored a method of representatively sampling the insect in trees; mapped the extent of the infestation; and determined the impact of defoliation on annual radial growth and mortality of infested trees. There is no reference in literature to Balch's outstanding and historically important report (Balch 1930). He transferred to Fredericton, New Brunswick, Canada soon afterward and other matters may have kept him from publishing this work.

Various other entomologists worked at the Coeur d'Alene lab during its existence (Fig. 9, 10) (Larsen 1979). Their work involved the biology and natural enemies (parasites and predators) of the mountain pine beetle (Donald De Leon); biology of the Douglas-fir beetle (William D. Bedard, Sr.); methods of controlling bark beetles, including toxic sprays (Archie L. Gibson); biology of the western spruce budworm; and surveys and control of insect infestations. Others who worked there (Evenden 1969) were: L. G. Baumhofer, Don LeLeon, Bill Willford, Bob Furniss (summer of 1929 during his Junior year at Syracuse University), W.D. Bedard, Sr., Roy Nagle, Robert E. Denton, Phillip C. Johnson, Galen Trostle, Red McComb, and David G. Fellin.

Evenden, by way of his background, was not cut out to be a researcher (however, see "Pine Butterfly") and those who were of that bent, such as Balch and De Leon, did not linger there, going to other locations and assignments. Output of Journal publication was lean. Emphasis was placed instead on reports; a total of over 500 were listed for the period 1915-1958 by Denton (1959), mostly emanating at Coeur d'Alene before transfer to Missoula. Evenden himself authored 211of them. They contain a wealth of biological and ecological information of relevance and of historical importance that is not available elsewhere. Nine copies were typed, consisting of the original and eight carbon copies. These reports were sent to whomever the subject of the report applied (e.g., Yellowstone NP, ranger districts, etc.), the Berkeley and Portland labs, western regional offices of the Forest Service, and the Bureau's Washington Office. Some reports have strayed but many are in the Forest Service Region 1 office in the Federal Building, Missoula. Consideration should be given to digitizing them and depositing them in a suitable archive. I have seen some of the reports pertaining to Yellowstone Park in the archives at Mammoth Headquarters, WY.

Bark beetles hold sway

Throughout the years, episodes of bark beetle infestations occurred in the northern Rocky Mountain forests and they received the greatest attention of the laboratory. The mountain pine beetle was particularly prominent and continual effort went toward developing improved methods to control it. A smattering of that work is presented here.

Piling and burning The relatively small size of infested lodgepole pine and the availability of horses and inexpensive labor in the Depression years lent themselves to yarding and decking felled trees (Fig. 11), which were then burned.

Peeling bark In the case of white pine, trees were often too big to yard and burn. The next experimental effort involved peeling the bark (Fig.12) and leaving the loose brood to predation (including by ants and mice) and the elements (Rust 1931, 1935).

Burning standing trees But, why even fall the lodgepole pine trees in the first place? So, the trunks of standing trees were sprayed with fuel oil from the ground and ignited in order to scorch the brood beneath the thin bark of this tree (Fig. 13).

"Tree medication" The notion of not having to fell the larger white pine trees led to experiments involving introducing a toxic solution into the basal trunk of recently infested trees (Fig. 14). This culminated in the "saw-kerf rubberized collar" method shown here. Brood mortality averaged 90% in trees treated within 3 months of the time of attack (Bedard 1938). Although he described this method as being more economic and practical than any other method of control at the time, toxic oil sprays supplanted it.

Spraying with insecticide Toxic oil sprays were developed to avoid having to burn brood, a method confined to short periods of low fire hazard. Gibson pioneered this work beginning in 1938 and continuing to 1952 (Gibson 1938-1952). At first, he used orthodichlorobenzene in fuel oil. Then, in order to reduce the volume of oil needed to be packed to inaccessible forest locations (Fig. 15), ethylene dibromide was formulated as a water emulsion. Thus, only the toxic component needed transport; water was available in the forest. Gibson's long list of reports dealing with toxic penetrating sprays is representative of the tenacious, plodding nature of work at the Coeur d'Alene lab. One publication resulted: Gibson (1943a).

Three million trees were sprayed on the Targhee and Teton National Forests, alone, between 1957-1969 using a portable motor powered sprayer and nozzle developed by Terrell (Figs. 16. A, B.). Finally, direct control was abandoned when Amman & Baker (1972) showed that, treated or not, the residual stand ended up the same over time. Thereafter, effort switched to silvicultural treatment as a better way to thwart the beetle.

Spruce budworm

Evenden visited Yellowstone N. P. on 9-10 June 1923 in response to the Park Superintendent's report of defoliated trees (Evenden 1923). He observed defoliated Douglas-fir (Fig. 17) at the head of Blacktail Deer Creek and along the south side of the Yellowstone River opposite Hell Roaring Creek. Moths appeared later and were thought to be the eastern spruce budworm, then known as *Cacoecia fumiferana* Clemens, later described as the western spruce budworm, *Choristoneura occidentalis* Freeman. While this infestation was running its course, a separate spruce budworm infestation was attracting attention in Cody Canyon, the popular eastern approach to the park. By 1929, alarm was being voiced to officials by the summer home and resort owners as noted by Evenden (1930):

> "With the spread of this epidemic into the forests noticeable to the layman, public opinion became insistent that something be done to prevent further destruction of these timber stands in order to preserve the beauty and economic value of the region."

Responding to the insistent call for action by residents of the area, Evenden made the first effort to control the budworm in the west in June 1929 when a total of 300 acres of infested trees were experimentally sprayed with mixtures of lead arsenate and water. Fish oil was added to help the poisonous spray adhere to foliage that would be ingested by feeding larvae. This sort of spray had been effective against larvae of the gypsy moth on deciduous trees in the eastern United States.

He used Evinrude forest fire pumps to apply the spray through 150 ft of hose. Spray solution was mixed by hand in two 55-gal barrels. Trouble was encountered on several counts. The spray only reached a height of 50 feet whereas some trees were over 100 feet tall. According to Evenden, "The effect secured with this equipment could be compared to the washing from a garden hose." Back at the barrels, the ingredients separated readily, "...it seemed nearly impossible to keep the mixture properly agitated and the oil from rising to the top."

An examination of these trees later in the season showed very little beneficial effects of the spray." Nonetheless, he called for another round in 1930.

Bigger, if not better, efforts to control budworms in Cody Canyon, 1930 – 1932

Fortuitously, better spray equipment lay close at hand in Yellowstone Park itself evidently acquired for spraying lodgepole pines infested with other defoliators (needle tiers and sawflies) near West Yellowstone (Fig.18). So, from 13 June to 7 July 1930, the Park's "high-power Fitzhenry Gupti sprayer" was used to apply 136,000 gals of spray containing 3864 lbs. of lead arsenate at a cost of $10,000 (Evenden 1931). The pump delivered 300 pounds of pressure through 1,500 feet of hose to a height of several hundred feet. Four or more crewmen were required to wrestle the lengthy hose, sometimes having to cross the Shoshone River to reach some of the summer homes and resorts (Fig. 19).

The spray had to be applied (Fig. 20) during the short time between opening of buds but before the budworm caterpillars could feed extensively on the developing needles. Crews worked two 8-hr shifts. Evenden was on the scene until 24 June when he left his field assistant, Vernon Lopp, in charge. During the second shift on 25 June the tank "stopped up". Lopp "made a check-up on the crews to learn who was missing, as we found someone's underwear in the spray tank."

His weekly report to Evenden continued: "Tuesday, July 1: Got both sides road from camp west of Holm Lodge, where spraying occurred 24 June. Holm management finds it can't feed its cows on lead arsenate and make them thrive. A year-old heifer, one of several that had been turned in to graze on a sprayed area following rain a few days ago, became ill Saturday afternoon and died Monday ... Nothing was said about it. I talked with Mrs. Shawfer and I think they intend to keep their stock away from arsenate from now on."

Looking back, Evenden commented that spraying in 1930: "...was intended to be an experimental project, however, "...due to the seriousness of the infestation, it quickly developed into a straight control operation with little thought of experimental values." He concluded that "... the results were so inconsistent that the operation ... could hardly be recommended as a method of control for future epidemics (Evenden 1931)."

However, Evenden's tenacity in the face of discouraging results continued. In 1931, numerous variations of treatment were tested but none seemed much better perhaps due in part to the complexity involved and resultant mistakes made by inexperienced field personnel and the pressure of working against time. But, worse for purposes of the tests, nature turned out to be a whimsical place in which to experiment. The budworm population suddenly declined from natural causes, making assessment of treatment effectiveness difficult. The combination of these problems is evident in Evenden's subsequent report (1932): 'It is difficult to measure results as (mistakenly) no larval counts were taken in untreated trees used as checks. Furthermore, ... as there is so little difference in the injury between the treated and untreated trees, it is even more difficult to weigh the value of these sprays and dusts."

Never the less, some lead arsenate was left over from the 1931 project and applied in 1932 to the following dude ranches including Holm Lodge (Fig. 21). Thereafter, the budworm appeared to diminish further in importance, due apparently to natural causes. By then, however, more than 260,000 gallons of spray containing thousands of pounds of lead arsenate had been applied and re-applied to inhabited areas of the canyon and along its roadsides.

How all that could happen is subtly apparent in the last report we have by Evenden (1933) that is devoted specifically to this outbreak of budworm in Cody Canyon:

> "Though this project has rather forcefully demonstrated the ineffectiveness of present methods of control against the spruce budworm it is believed by many (occupants of the area) that the reduction secured from such treatment has been sufficient to preserve the trees around the "Dude Ranches" and resorts for which the protection was especially desired."

Pine butterfly

An outbreak of the pine butterfly occurred during 1921-1923 on 27,000 acres in the upper Little Salmon and Payette River drainages near McCall and New Meadows (Evenden 1926). The only previously known Idaho infestation had occurred near Moscow during 1896-1898. Tall, mature, trees were severely defoliated in 1922, the peak year (Fig. 22). In 1923, the infestation was confined largely to small trees, due evidently to there being no needles on the tall trees on which to lay eggs.

Up to this time there was confusion concerning the seasonal history of the butterfly. Some thought that it was "... much like its near relative the cabbage butterfly in having continuous series of broods during summer, probably three or four." Others thought that it overwintered as pupae. Evenden (1926) clarified the seasonal history as follows: One generation occurred per year. Eggs were laid in August in rows on needles where they overwintered. Eggs hatched when new needles began to appear in the following spring. Larvae matured in late July and lowered themselves to the ground on silken threads where they pupated on various objects. Adults emerged in 15-20 days and immediately mated and began laying eggs.

He also marked 100 representative trees in 1924 and examined them until 1933. Of 84 severely defoliated trees, 12 died from defoliation alone and 14 died from a combination of defoliation and infestation by the western pine beetle. No mortality occurred in moderately or lightly defoliated trees. Eighty-nine percent of the study trees failed to add any basal increment for several years afterward (Evenden 1940).

This study stands in contrast from Evenden’s other work which characteristically consisted of endless surveys and rendering technical assistance with control projects. He published nothing else of this nature. What compelled him in this instance is unknown; however, he may have felt the need to demonstrate some proficiency in more strictly entomological endeavor. At any rate, he used this study as a thesis and was granted a Forest Engineer degree from Oregon State College in 1936. How that came about is not evident and there is no record of his having ever left Coeur d’Alene to take any classes. He seemed self conscious about this study and the resulting degree; his oral history interview made no mention of either (Larson 1979).

Douglas-fir tussock moth

In May 1947, an armada of assorted aircraft took aloft in northern Idaho to control an outbreak of the Douglas-fir tussock moth that threatened to defoliate 400,000 acres of forest centered in Latah County (Furniss 2004). It was the largest aerial spraying project undertaken up to that time in western forests. Coincidentally, the western spruce budworm had begun to infest vast areas of forests in Oregon and Washington. The apparent success of the Idaho tussock moth control project was monitored by counterparts in Oregon who tested the spray successfully against the budworm in 1948. Thereafter, 9 million acres were sprayed during 1949 - 1958, mostly in Oregon, Washington, and Idaho but also including Montana and the northern portion of Yellowstone National Park. This project also set a precedent for federal and state cost-sharing of forest insect control on private land.

Evenden was in charge of entomological aspects, assisted by Phillip C. Johnson who had transferred to Coeur d'Alene from the Berkeley Forest Insect Laboratory. No precedent existed for such large scale spraying of western forests. However, a spray consisting of one pound of DDT in one gallon of oil per acre had been used against the gypsy moth in the eastern United States and was chosen for this project. Likewise, no contracts for such flying had been issued. Twenty-seven invitations to bid were sent to flying firms. Five responded. Successful contractors were Johnson Flying Service, Missoula, MT and Central Aircraft, Inc., Yakima, WA. Johnson's fleet of eight smaller, single-engine aircraft: Stearman biplanes, and Stinson, Fairchild, and Travelair monoplanes. The project was completed on 2 July. In the course of spraying, three of Central's aircraft crashed: a Travelair ground-looped while landing, another Travelair crashed because of engine failure, and a Stearman was caught in a downdraft at the head of a canyon (Fig. 23). The pilots were only slightly injured.

Conclusion

The Coeur d'Alene facility spanned 36 years, a period of great change. In the beginning, little was known of the make-up of the insects in the vast surrounding old growth forests, which themselves were mostly inaccessible. Bark beetles dominated. Stirred on by a strong willed Hopkins, much emphasis was placed on suppressing their populations by direct means. A never ending series of tests were made to develop better ways of doing that. It seems strange now that beetles were not recognized as only symptoms of tree and stand conditions and effort made to alleviate those conditions. The reasons appear to be that the Division of Forest Insect research was largely a service organization vested with the responsibility to provide technical information and supervision of control operations on all forest ownerships. It had no land of its own to manage. The many companies and government agencies sought action to address ever new outbreaks. Any action was better than no action. Evenden could not have denied their pleas and the magnitude of that sort of work more than matched the resources of his staff. Even so, Evenden was least of all a researcher; a person molded by his early background and most at home in some control camp (Fig 24). During his stay in Coeur d'Alene, he fitted the time and was universally well thought of by all. At the 1969 conference here in Coeur d'Alene, Evenden spoke at a luncheon (Evenden 1969) arranged by his former employees (Fig. 25). The title of his talk was "Those were the days".

References

Amman, G. D., and B. H. Baker. 1972. Mountain pine beetle influence on lodgepole pine stand structure. Journal of Forestry 70:204-209.

Balch, R. E. 1930. The spruce budworm epidemic on lodgepole in Wyoming. USDA Bur. Entomol. Coeur d'Alene For. Insect Lab. Typed report, 33pp. illus. (Special Collections and Archives Library, Univ. Idaho, Moscow).

Bedard, W.D. 1938. Control of the mountain pine beetle by means of chemicals. Journal of Forestry 36: 35-40.

Burke, H. E. 1946. My recollections of the first years of forest entomology. Bureau of Entomology and Plant Quarantine, Berkeley, California. Unpublished report.

Denton, R. E. 1959. Unpublished reports by personnel of the Coeur d'Alene Forest Insect Laboratory (1915-1954) and Missoula Forest Insect Lab (1955-1958). USDA, For. Serv. INT, Missoula, MT. A bibliography. Special Collections and Archives Library, Univ. Idaho, Moscow.

Evenden, J. C. 1969. Luncheon address, 20th WFIWC, Coeur d'Alene, Idaho, March 10-13, 1969.

Evenden, J.C. 1940. Effects of defoliation by the pine butterfly upon ponderosa pine. Jour. Forestry 38(12): 949-955.

Evenden, J. C. 1933. Experimental spraying for the control of the spruce budworm in the Cody Canyon, Shoshone National Forest, 1932. Cd'A FIL. 14 pp.

Evenden, J. C. 1932. Experimental spraying for the control of the spruce budworm in the Cody Canyon, Shoshone National Forest, 1931. Cd'A FIL. 63 pp., illus.

Evenden, J. C. 1931. Experimental spraying for the control of the spruce budworm in the Cody Canyon, Shoshone National Forest, 1930. Cd'A FIL. 43 pp., illus.

Evenden, J. C. 1930. Forest insect conditions in the Yellowstone National Park, season of 1930. Cd'A FIL. 9 pp.

Evenden, J.C. 1926. The pine butterfly, Neophasia menapia Felder. Jour. Agric. Res. 33(4): 339-344.

Evenden, J. C. 1923. Defoliation of timber stands within the Yellowstone National Park, 1923. Cd'A FIL. 12 pp., illus.

Furniss, M. M. 2010. Beginnings of American forest entomology: The role of Andrew Delmar Hopkins (1857–1948). American Entomologist 56: 78-87.

Furniss, M. M. 2004. 1947 Douglas fir tussock moth outbreak in northern Idaho: Target of the largest aerial spraying project in western forests. Latah Legacy. 33 (1): 1-8.

Furniss, M. M. 2003. Forest entomology in the northern Rocky Mountains: 1909-1917, as reflected in the correspondence between Josef Brunner and A. D. Hopkins. Amer. Entomol. 49: 102-111.

Gibson. A.L. 1952. Tests of penetrating sprays to control bark beetles-1951. Cd'A FIL. 10 pp.

Gibson. A.L. 1951. Experiments to test the effectiveness of penetrating sprays against the Douglas fir beetle. Cd'A FIL. 9 pp.

Gibson. A.L. 1950. Experiments to determine the effectiveness of penetrating sprays on mountain pine beetle infested western white pine windfalls. Cd'A FIL. 8 pp.

Gibson. A.L. 1944a. Tests of penetrating sprays to control the mountain pine beetle in western white pine-1943. Cd'A FIL. 15 pp.

Gibson. A.L. 1944b. Fall control with penetrating sprays against the mountain pine beetle in western white pine-1943. Cd'A FIL. 9 pp.

Gibson, A.L. 1943a. Penetrating sprays to control the mountain pine beetle. Journal of Economic Entomology 36:396-398.

Gibson. A.L. 1943b. Water emulsions for penetrating sprays. Cd'A FIL. 12 pp.

Gibson. A.L. 1943c. Spring control of the mountain pine beetle in western white pine with penetrating sprays-1942. Cd'A FIL. 20 pp.

Gibson. A.L. 1943d. Laboratory tests of emulsions to be used for experimental control of the mountain pine beetle in western white pine-1942. Cd'A FIL. 5 pp.

Gibson. A.L. 1942a. Fall control of the mountain pine beetle in western white pine with penetrating sprays-1941. Cd'A FIL. 17 pp.

Gibson. A.L. 1942b. Experiments with penetrating sprays conducted in western white pine, 1940-41. Cd'A FIL. 11 pp.

Gibson. A.L. 1942c. Experiments with penetrating sprays conducted in western white pine, 1940-41. Cd'A FIL. 11 pp.

Gibson. A.L. 1941. Experiments with penetrating sprays conducted in lodgepole and whitebark pine in 1940. Cd'A FIL. 61 pp

Gibson. A.L. 1941. Experiments with penetrating sprays conducted in lodgepole and whitebark pine in 1940. Cd'A FIL. 61 pp.

Gibson. A.L. 1940. Spraying with various penetrating oils in the search for a better method of controlling the mountain pine beetle in lodgepole pine-1939. Cd'A FIL. 13 pp.

Gibson. A.L. 1939. Progress report-spraying with penetrating oils to control the mountain pine beetle in lodgepole pine. Cd'A FIL. 42 pp.

Gibson. A.L. 1938. Progress report-spraying with lethal oil to control the mountain pine beetle in lodgepole pine. Cd'A FIL. 48 pp.

Hopkins, A.D. 1891. Forest and shade tree insects. II. Black spruce (*Picea mariana*). Preliminary Report. W. Va. Agric. Exper. Sta.. Bull. 18:93-102

Hopkins, A. D. 1899. Report on investigations to determine the cause of unhealthy conditions of spruce and pine from 1880-1893. W. Va. Agric. Exper. Sta. Bull. 56: 197-461.

Larson, R. C. 1979. Western forest entomology history – Interview of James C. Evenden, Coeur d'Alene, ID, 23 March 1979. (Edited by M. M. Furniss, 1989, copy in author's possession).

Rust, H. J. 1947. Migration and nesting of nighthawks in northern Idaho. The Condor 49(5): 177-188.

Rust, H. J. 1946. Mammals of Northern Idaho. Jour. Mammalogy 27(4): 308-327.

Rust, H.J. 1935. The role of predatory agents in the artificial control of the mountain pine beetle. J. Econ. Entomol. 28: 688-691.

Rust, H.J. 1931. Final report on the role of ants, centipedes, and rodents destructive to broods of the mountain pine beetle exposed by the peeling method of control. Cd'A FIL. 40 pp.

Terrell, T. T. 1977. In Maunder, E.R. 1977. Oral history volume of forest entomology in the west. Forest History Society and USDA For. Serv. Letter to Ralph C. Hall. April 11, 1977. Typed 6pp. Special Collections and Archives Library, Univ. Idaho, Moscow.

Fig. 1. Andrew Delmar Hopkins at the time of his stepping down from head of the Division of Forest Insect Investigations in 1922 at age 65. This portrait is signed and dated. It was given to James C. Evenden, then in charge of the Coeur d'Alene, Idaho, Forest Insect Laboratory.

Fig. 2. When Hopkins took over the new Division of Forest Insect Investigations in 1902, his first order of business was to station Jesse Web at Elmore, SD, in the Black Hills Forest Reserve to study an outbreak of the Black Hills beetle, *Dendroctonus ponderosae* (now *D. monticolae*). Web was the first college-trained forest entomologist in America; Hopkins himself never attended college, yet was granted an honorary PhD by West Virginia University. Shown from left: Webb, two pathologists, and Hopkins, July 1902. (Burke 1946)

Fig. 3. Josef Brunner (left) and Jesse L. Webb on a field trip in Montana during July 1910, a few weeks after Brunner had suffered a broken leg. (Photo from Burke 1946).

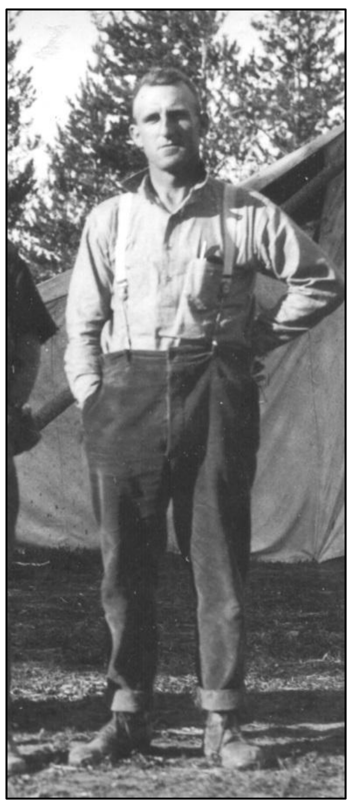


Fig. 4. James C. Evenden

Fig. 4A. Evenden at the Coeur d'Alene Field Station on lower 7th Street, ca 1921.


Fig. 5. Henry Rust was hired by Evenden on July 1, 1921. He was a commercial photographer with wide interests. He published on the rodents of Idaho, and his long-term observations of the Pacific nighthawk (Condor magazine). He retired in 1943.

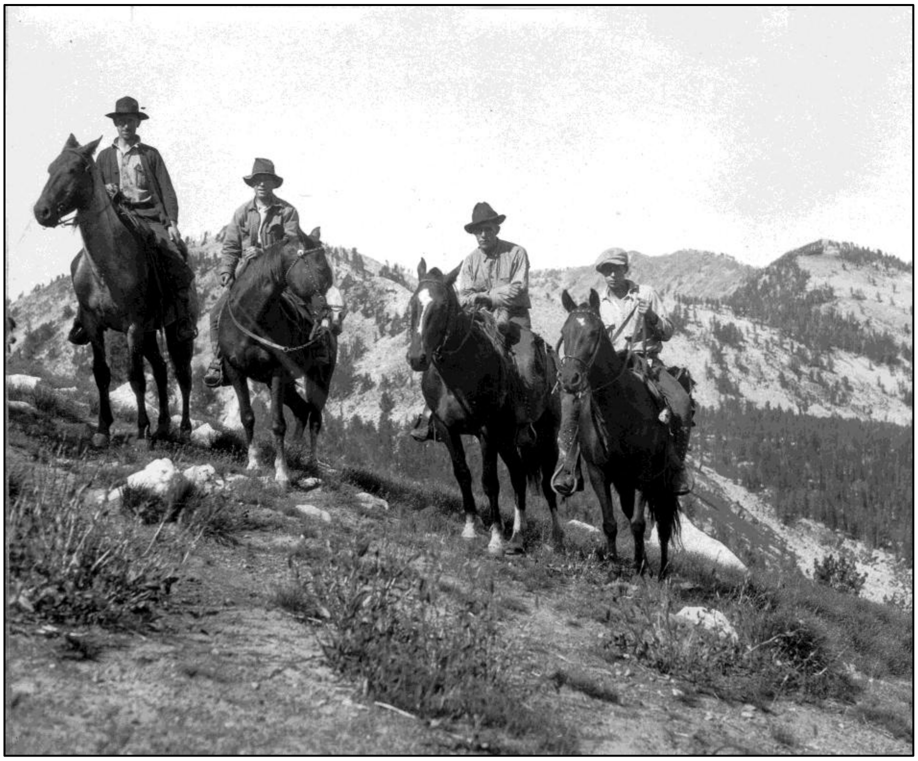


Fig. 5A. Henry Rust (second from left) on Pardner with insect survey crew, August 30, 1925. They are on the divide between Bare Hill and Kent Mountain at the heads of Sleeping Child, Martin Creek and Ross Fork (Rock Cr.), Bitterroot N.F, Montana.

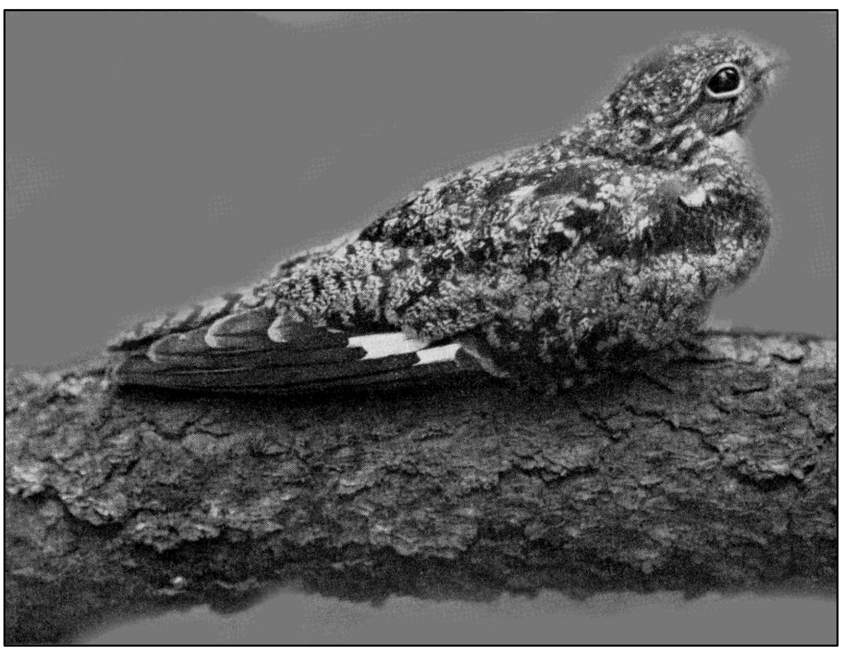


Fig. 6. A young Pacific nightwawk taken from an article in The Condor by Henry Rust.

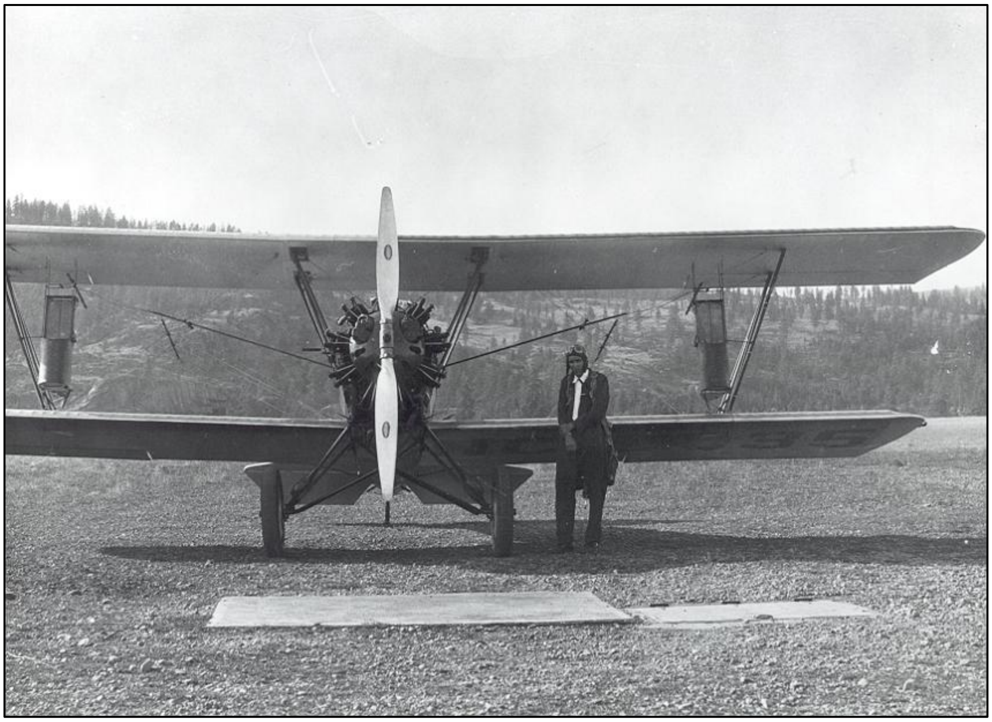


Fig. 7. Terrell and biplane in which he made the first forest insect aerial survey in the northern Rocky Mountains, 1930.

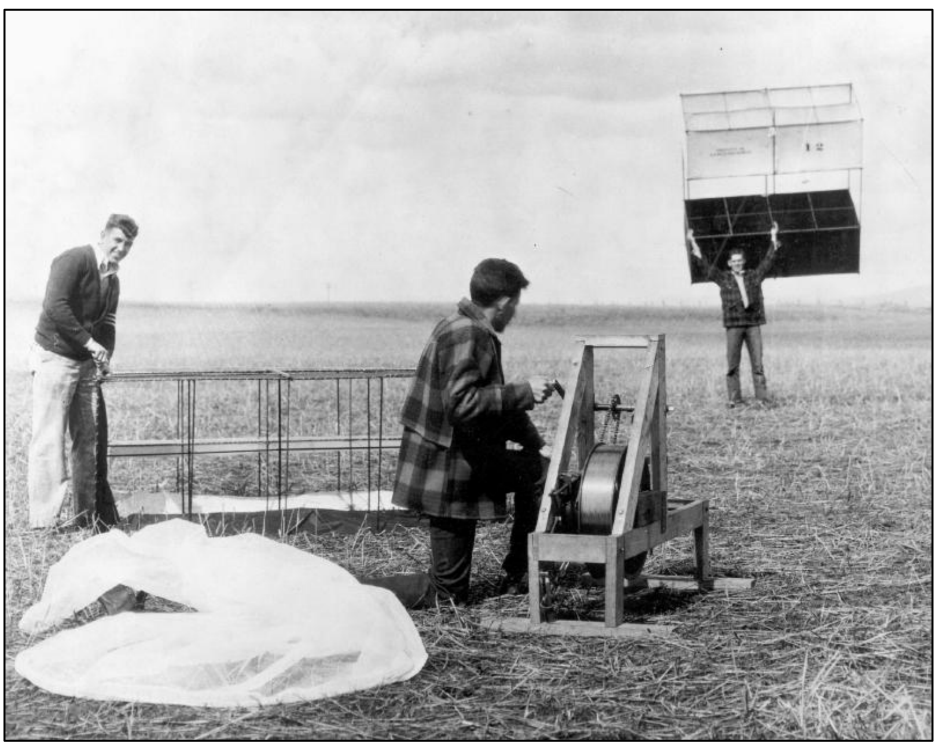


Fig. 7A. Tom Terrell (center) preparing to fly a weather bureau kite equipped with nets to study flight and dissemination of the mountain pine beetle in an area adjacent to lodgepole pine during an outbreak of the beetle. Only one bark beetle was caught; it was not a mountain pine beetle. Big Hole Basin, Montana.

Fig. 8. James C. Evenden (left) and Tom T. Terrell examining map of locations of mountain pine beetle infestations on the Targhee and Teton National Forests adjacent to Yellowstone National Park, ca 1948.

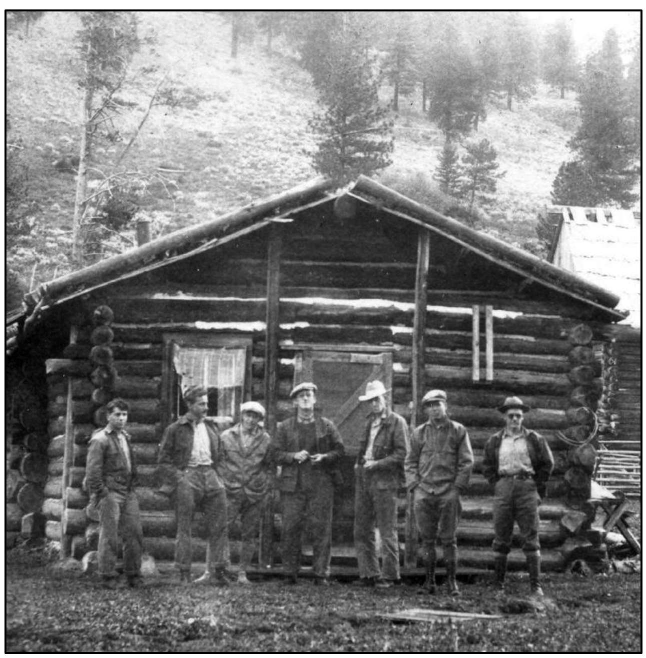


Fig. 9. Coeur d'Alene Forest Insect Lab personnel and F.C. Craighead of Wash. D.C. at Wetzsteon cabin, East Fork Bitterroot R., MT July 5, 1928. L to R: DeLeon, Balch, Craighead, Evenden, Terrell, England, Gibson. DeLeon studied mountain pine beetle parasites, predators, and other associated insects at this location.

Fig. 10. Staff of the Coeur d'Alene FIL and Washington Office visitors on a field trip in the Coeur d'Alene N.F, Idaho, ca 1952. Front from left: Archie Gibson, James A. Beal (WO), James C. Evenden, Phillip C. Johnson. Standing: Harvey J. MacAloney (WO), Robert E, Denton, Galen C. Trostle, Tom T. Terrell. Beal was the 3rd and last Chief of Forest Insect Investigations, which was disbanded in 1953 and transferred to the Forest Service. Evenden established the Coeur d'Alene lab in 1919 and was its leader until he retired and it was moved to Missoula, MT in Jan. 1955.

Fig. 11. Yarding and decking lodgepole pine prior to burning to destroy mountain pine beetle broods.

Fig. 12 The mountain pine beetle was a major cause of white pine mortality in Idaho and various methods were developed in attempts to control it. One such method involved peeling bark while the broods were immature as shown here on the Coeur d'Alene National Forest ca 1930.

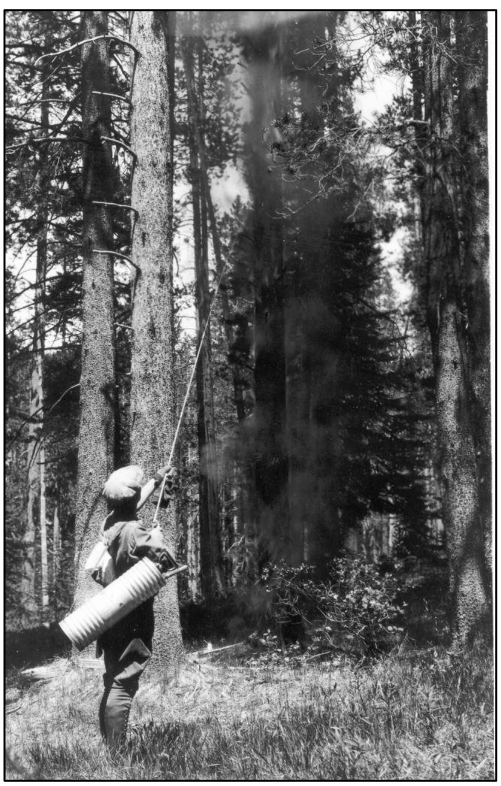


Fig. 13. Burning a standing lodgepole pine infested with mountain pine beetle. Trunk was sprayed with fuel oil prior to ignition.

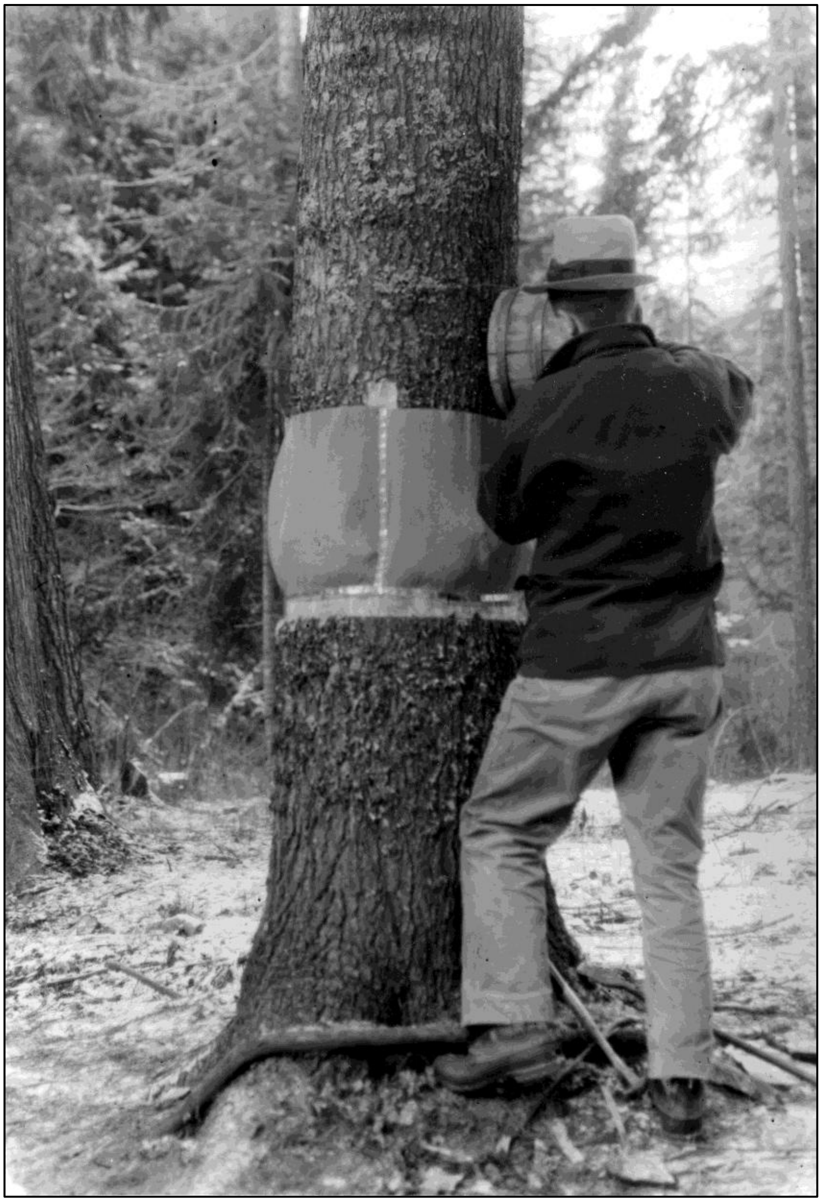


Fig. 14. W.D. Bedard, Sr. applying a copper sulphate solution to a girdle on the trunk of a white pine recently infested by the mountain pine beetle, Coeur d'Alene N.F. ca 1931. This photo was filed under "Tree medication" at the lab. This technique was developed over several years by the Coeur d'Alene lab personnel involving different methods of introducing the poison into the xylem, culminating in the "saw-kerf rubberized collar" method shown here. In all, 600 lodgepole pines and 1,254 white pines were treated. Bedard (1938) concluded that the method was limited to trees in which attack was less than 3 months old and that brood mortality was over 90%. Although this method was described as being more practical than any other method of control at the time, toxic oil sprays supplanted it.

Fig. 15. Pack outfit returning empty drums and pack boxes to end of road. Penetrating oil spray was transported in 5 gallon cans to inaccessible areas of lodgepole pine infested with mountain pine beetle. Various formulations of insecticide and spray equipment were developed during 1938-1952 by Archie Gibson and Tom Terrell of the Coeur d'Alene lab and used extensively in Rocky Mountain states until direct control was discontinued in approximately 1972. Wasatch N.F. 1940.

Fig. 16. A. Gasoline-motor-powered sprayed developed by Tom Terrell for applying insecticide formulations to kill bark beetle brood beneath bark of infested trees. It was designed originally with handles for carrying and operation by two people and consisted of a 2-cycle gasoline motor, a pump and a 5-gallon Jeep can containing the insecticide. Three million trees were sprayed with this equipment on the Targhee and Teton National Forests between 1957-1969. Direct control was abandoned when Amman & Baker (1972) showed that, treated or not, the residual stand ended up the same over time. Shown here is LeRoy Kline, using a pump borrowed from Terrell to test a formulation for preventing infestation of the Douglas-fir beetle in a felled tree. Kline was a summer assistant in 1959 on Mal Furniss' study in Idaho.

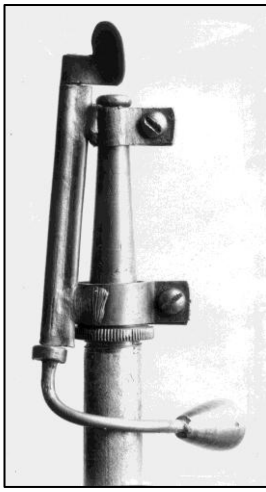


Fig. 16. B. Spray nozzle invented and patented by Tom Terrell. "The deflector attachment, operated by the flip of the fire nozzle holder, changes the solid stream of liquid issuing from the fire nozzle into a fan-shaped spray. The weight of the metal rod holding the deflector, holds the deflector in proper position when in use and, when flipped to the other side of the pipe holding the nozzle, permits use of the solid steam (for reaching higher on the tree stem)". Terrell also invented a telescoping spray wand to which this nozzle was attached.

Fig. 17. **Spruce budworm is discovered in the west, 1923**. Evenden visited Yellowstone N. P. in June, 1923 in response to the Park Superintendent's report of defoliated trees (Evenden 1923). He observed defoliated Douglas-fir and Engelmann spruce at the head of Blacktail Deer Creek and along the south side of the Yellowstone River opposite Hell Roaring Creek. Examination disclosed only empty pupal cases still clinging to trees from the previous year. The pupal cases looked to him to be those of the eastern spruce budworm, an insect unknown in the western United States until this infestation and concurrent ones in Idaho. He returned in early July to find abundant larvae devouring new foliage. The suspected identity of the insect was confirmed on his third visit in August when moths were in flight around the afflicted trees. In time, the insect became known as the western spruce budworm. Note: Evenden wrote on this photo: "Douglas fir killed by the spruce budworm – Crescent Hill, YNP. July 1924."

Fig 18. Equipment used for spraying spruce budworm and other defoliators at entrances to YNP.

Fig. 19. In an attempt to control the spruce budworm in Cody Canyon, Wyoming, during 1930, a "high-power Fitzhenry Gupti sprayer" was used to apply 136,000 gals of spray containing 3864 lbs. of lead arsenate (Evenden 1931). The pump delivered 300 pounds of pressure through 1,500 feet of hose to a height of several hundred feet. Four or more crewmen were required to wrestle the lengthy hose, sometimes having to cross the Shoshone River to reach some of the summer homes and resorts.

Fig. 20. Spraying lead arsenate on Douglas fir infested by the western spruce budworm. Cody Canyon, Wyoming. 1934.

Fig. 21. Spraying lead arsenate to control spruce budworm at Holm Lodge

Fig. 22. Ponderosa pine defoliated by the pine butterfly in Idaho, 1922. Defoliated trees experienced growth reduction (arrow) lasting several years. Some trees died.

Wreckage of Jim Larkin's Stearman

Ground-looped Travelair at airstrip north of Laird

Fig. 23. Wrecked airplanes, Douglas-fir tussock moth control project 1947.

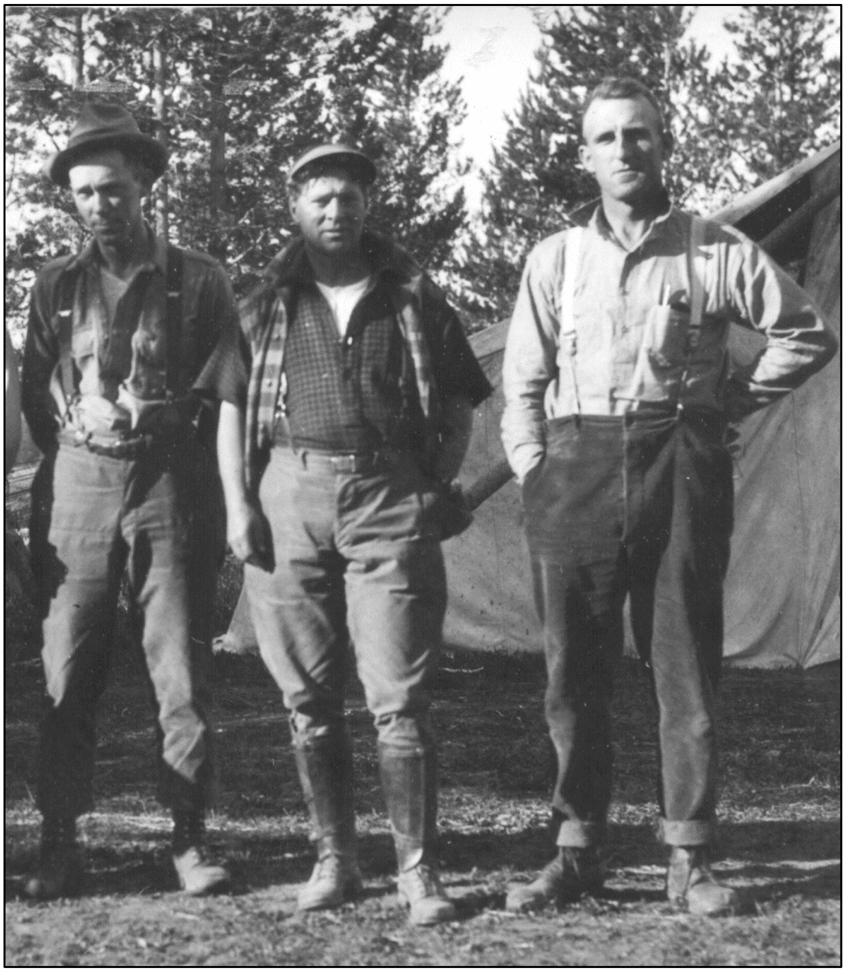


Fig. 24. J.C. Evenden (right) at headquarters camp, Big Hole Basin mountain pine beetle control project, Beaverhead N.F., Montana, 1927.

Fig. 25. Jim Evenden gave a luncheon talk on the history of the Coeur d'Alene Lab at the 1969 WFIWC. Attending were these former employees, from left: Phil Johnson, Dave Fellin, Red McComb, Bob Denton, Evenden, Tom Terrell, and Galen trestle. Johnson succeeded Jim as leader when the lab was transferred to Missoula in 1955.

LIST OF ATTENDEES

Last Name	First Name	Affiliation	Email
Aflitto	Nicholas	Northern Arizona University	na279 “at” nau.edu
Allen	Kurt	USDA Forest Service	kallen “at” fs.fed.us
Ambourn	Angie	USDA Forest Service	akambourn “at” fs.fed.us
Baker	Jacob	Northern Arizona University	jpb247 “at” nau.edu
Bennett	Dayle	USDA FS FHP	ddbennett “at” fs.fed.us
Bentz	Barbara	Rocky Mountain Research Station	bbentz “at” fs.fed.us
Billings	Ronald	Texas A&M Forest Service	rbillings “at” tfs.tamu.edu
Blackford	Darren	USDA Forest Service - FHP	dblackford “at” fs.fed.us
Bleiker	Kathy	Canadian Forest Service	kbleiker “at” nrcan.gc.ca
Boone	Celia	University of Northern British Columbia	boone “at” unbc.ca
Bracewell	Ryan	University of Montana	ryan.bracewell “at” umontana.edu
Bulaon	Bev	US Forest Service	bbulaon “at” fs.fed.us
Burke	Jordan	The University of British Columbia	jordan.lewis.burke “at” gmail.com
Burr	Stephen	Northern Arizona University	burrste36 “at” gmail.com
Cain	Bob	USDA Forest Service	rjcain “at” fs.fed.us
Cardoza	Yasmin	North Carolina State University	yasmin_cardoza “at” ncsu.edu
Ciesla	Bill	Forest Health Management International	
Ciesla	Pat	Guest	
Clark	Erin	University of Northern British Columbia	eclark1 “at” unbc.ca
Cluck	Daniel	US Forest Service	dcluck “at” fs.fed.us
Coleman	Tom	Forest Health Protection	twcoleman “at” fs.fed.us
Cook	Stephen	University of Idaho	stephenc “at” uidaho.edu
Cruz	Rob	US Forest Service	rcruz “at” fs.fed.us

Last Name	First Name	Affiliation	Email
Czokajlo	Darek	Alpha Scents, Inc	darek “at” alphascents.com
Davis	Gina	Idaho Department of Lands	gdavis “at” idl.idaho.gov
Davis	Thomas	University of Idaho	tsdavis1 “at” gmail.com
DeMarco	Ari	Oregon State University	ari.demarco “at” oregonstate.edu
Douce	G Keith	Center for Invasive Species & Ecosystem Health	kdouce “at” uga.edu
Eager	Tom	USDA Forest Service	teager “at” fs.fed.us
Eckberg	Tom	Idaho Department of Lands	teckberg “at” idl.idaho.gov
Eckberg	Nina	Panhandle Lakes RC&D	
Egan	Joel	USDA Forest Service	jegan “at” fs.fed.us
Eglitis	Andris	USDA Forest Service	aeglitis “at” fs.fed.us
Ellenwood	Jim	Forest Service, Forest Health	jellenwood “at” fs.fed.us
Evans	Douglas	BLM	devans “at” blm.gov
Fettig	Christopher	USDA Forest Service, PSW Research Station	cfettig “at” fs.fed.us
Flowers	Rob	Oregon Department of Forestry	rflowersWodf.state.or.us
Fowler	Don	Contech Enterprises	don.fowler “at” contech-inc.com
Gannon	Amy	Montana DNRC	agannon “at” mt.gov
Gibson	Carol	Guest	
Gibson	Ken	USFS-Retired	
Gonzalez	Lilly	ChemTica USA	lilly “at” pheroshop.com
Grady	Amanda	USDA Forest Service	agrady “at” fs.fed.us
Graham	Elizabeth	USDA Forest Service	eegraham “at” fs.fed.us
Graves	Andrew	Forest Service	adgraves “at” fs.fed.us
Grosman	Donald	Arborjet Inc.	dgrosman “at” arborjet.com
Grulke	Nancy	USFS-WWETAC	ngrulke “at” fs.fed.us

Last Name	First Name	Affiliation	Email
Hansen	Matt	Rocky Mountain Research Station	matthansen “at” fs.fed.us
Hanula	Jim	USDA Forest Service	jhanula “at” fs.fed.us
Hayes	Chris	USDA Forest Sevice	cjhayes “at” fs.fed.us
Helmuth	Von	USFS-Forest Health Protection	vhelmuth “at” fs.fed.us
Hicke	Jeffrey	University of Idaho	jhicke “at” uidaho.edu
Hofstetter	Richard	Northern Arizona University	rich.hofstetter “at” nau.edu
Hostetler	Bruce	4156 SW Corbett Ave	
Hrinkevich	Kate	Oregon State University	hrinkevk “at” onid.orst.edu
Jackson	Marcus	USFS-Forest Health Protection	
Johnson	Mike	WA STATE DNR	mike.johnson “at” dnr.wa.gov
Johnson	Kim	USFS-Payette NF	
Jones	Michael	UC Davis	mjones “at” ucdavis.edu
Jorgensen	Carl	USDA FS FHP	cljorgensen.fs.fed.us
Kaiser	Mathias	University of Calgary	mkaiser “at” ucalgary.ca
Keane	Robert	USDA FS RMRS	rkeane “at” fs.fed.us
Kegley	Sandra	USFS-Forest Health Protection	skegley “at” fs.fed.us
Keyes	Colleen	Utah Division of Forestry, fire and state lands	colleenkeyes “at” utah.gov
Klepzig	Kier	USDA Forest Service	kklepzig “at” fs.fed.us
Koch	Les	Wyoming State Forestry Division	leslie.koch “at” wyo.gov
Kohler	Glenn	WA STATE DNR	glenn.kohler “at” dnr.wa.gov
Kolb	Thomas	Northern Arizona University	tom.kolb “at” nau.edu
Kruse	James	USDA Forest Service	jkruse “at” fs.fed.us
Lachowsky	Leanna	University of Calgary	leanna.lachowsky “at” gmail.com
Lazarus	Laura	USDA FS FHP	llazarus “at” fs.fed.us
Livingston	Ladd	Retired-Idaho State Entomologist	pzambino “at” fs.fed.us

Last Name	First Name	Affiliation	Email
Marciniak	Amberly	The University of British Columbia	amberly.marciniak "at" gmail.com
Marsh	Terri	Guest	
Marshall	Christopher	Oregon State University	marshach "at" science.oregonstat.edu
Mask	Roy	USDA Forest Service	rmask "at" fs.fed.us
McConnell	Timothy	USFS-Retired	
Meddens	Arjan	University of Idaho	ameddens "at" uidaho.edu
Mehmel	Constance	Forest Service	cmehmel "at" fs.fed.us
Mercado	Javier	Colorado State University	j_mercadopr "at" yahoo.com
Miller-Pierce	Mailea	Washington State University	m.miller-pierce "at" email.wsu.edu
Munson	Steve	USDA Forest Service - FHP	smunson "at" fs.fed.us
Murray	Dr. Bill	JEMA Management, LLC	
Nelson	Chad	USDA FS FHP	cwnelson "at" fs.fed.us
Nicholson	Stephen	Valent BioSciences	stephen.nicholson "at" valent.com
Oehlschlager	Cam	ChemTica USA	cam "at" pheroshop.com
Oester	Paul	OSU Extension Service	paul.t.oester "at" oregonstate.edu
Owen	Donald	CA Dept. of Forestry and Fire Protection	don.owen "at" fire.ca.gov
Paine	Timothy	University of California Riverside	timothy.paine "at" ucr.edu
Paul	Debbie	BLM	dkpaul "at" blm.gov
Pederson	Lee	USFS-Forest Health Protection	lpederson "at" fs.fed.us
Pena	Jorge E	University of Florida	jepena "at" ufl.edu
Peralta-Vazquez	Haydee	University of Calgary	ghperalt "at" ucalgary.ca
Pfammatter	Jesse	University of Wisconsin - Madison	jesse.pfammatter "at" gmail.com
Polinko	Adam	Northern Arizona University	adam.polinko "at" nau.edu
Powell	James	Utah State University	jim.powell "at" usu.edu
Rabaglia	Bob	US Forest Service	brabaglia "at" fs.fed.us

Last Name	First Name	Affiliation	Email
Randall	Carol	USFS-R1/4 Biological Control	crandall “at” fs.fed.us
Reboletti	Danielle	USDA Forest Service - FHP	dreboletti “at” fs.fed.us
Rehberg	Richard	USFS-Payette NF	
Reid	Mary	University of Calgary	mreid “at” ucalgary.ca
Riel	Bill	Canadian Forest Service	bill.riel “at” nrcan.gc.ca
Ripley	Karen	Washington State DNR	karen.ripley “at” dnr.wa.gov
Roberts	Lona	Guest	
Roberts	Fred C.	IEES	frdroberts “at” aol.com
Robinson	Anthony	The University of British Columbia	anthonypeterwilliam “at” gmail.com
Ross	Darrell	Oregon State University	darrell.ross “at” oregonstate.edu
Ryerson	Daniel E	Forest Service	dryerson “at” fs.fed.us
Sandoval	Stephani	Idaho Department of Lands	teckberg “at” idl.idaho.gov
Sapio	Frank	Forest Service, Forest Health	fsapio “at” fs.fed.us
Scarbrough	Dwight	USDA FS FHP	dscarbrough “at” fs.fed.us
Schaupp	Bill	USDA-Forest Service, FHP	bschaupp “at” fs.fed.us
Schotzko	Kendra	University of Idaho	schotzko “at” unbc.ca
Schwandt	John	USFS-Forest Health Protection	jschwandt “at” fs.fed.us
Shaw	David	Oregon State University	dave.shaw “at” oregonstate.edu
Sheehan	Kathy	USDA FOREST SERVICE	ksheehan “at” fs.fed.us
Six	Diana	University of Montana	diana.six “at” cfc.umt.edu
Smith	Eric	Forest Service, Forest Health	elsmith “at” fs.fed.us
Smith	Laine	University of Idaho	smit7910 “at” vandals.uidaho.edu
Snyder	Cynthia	USFS Region 5, Forest Health Protection	clsnyder “at” fs.fed.us
Sontag	Scott	USDA FS, R01, FHP	ssontag “at” fs.fed.us
Spiegel	Lia	US Forest Service	bccarlson3 “at” gmail.com

Last Name	**First Name**	**Affiliation**	**Email**
Steed	Brytten	USDA Forest Service	bsteed "at" fs.fed.us
Stephens	Sky	Colorado State Forest Service	sky.stephens "at" colostate.edu
Sturdevant	Nancy	USDA Forest Service	nsturdevant "at" fs.fed.us
Sullivan	Brain	USDA-FS-SRS	briansullivan "at" fs.fed.us
Sweeney	William	University of Idaho	william.p.sweeney "at" gmail.com
Takahashi	Curtis	Ca. Dept. of Food and Agriculture	ctakahashi "at" cdfa.ca.gov
Thomson	Bruce	Contech Enterprises Inc.	bruce.thomson "at" contech-inc.com
Toone	Chelsea	Utah State University	chelseatoone "at" gmail.com
Vandygriff	Jim	USDA ROCKY MOUNTAIN RESEARCH	jvandygriff "at" fs.fed.us
Wakarchuk	David	Synergy Semiochemicals Corp	david "at" semiochemical.com
West	Dan	Colorado State University	drwest73 "at" gmail.com
Wilfong	Candee	USFS-Forest Health Protection	cwilfong "at" fs.fed.us
Willhite	Elizabeth	USDA Forest Service	bwillhite "at" fs.fed.us
Williams	Wyatt	Oregon Department of Forestry	wwilliams "at" odf.state.or.us
Wulff	Doug	USFS-Forest Health Protection	dwulff "at" fs.fed.us
Wytrykush	Debra	The University of British Columbia	dwytrykush "at" hotmail.com
Zambino	Paul	USDA-FS-R1-FHP	
Stewart	Charles	USDA-FS-R1	
Carman	Flo	Guest of Sky Stevens	
Beckman	David		
Dewey	Jed		